Marine Fisheries REVIEW

November 1980

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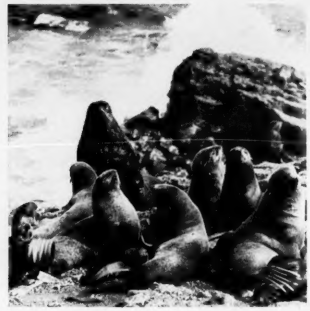
Marine Mammals and Oil

Marine Fisheries REVIEW



Northern fur seals, *Callorhinus ursinus*. NMFS photo by V. Scheffer.

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National Marine Fisheries Service

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Offshore Petroleum Resource Development and Marine Mammals: A Review and Research Recommendations

J. R. GERACI and D. J. St. AUBIN

Introduction

The possible effects of oil and oil-industry activities on marine mammals are a subject of great concern. All marine mammals inhabit surface water to breathe and some to feed, potentially exposing them to spilled oil by contact, inhalation, or ingestion. Nearshore accumulation of oil could directly affect inshore-dwelling cetaceans, manatees, and virtually all pinnipeds and sea otters.

Moreover, all but the manatees are high- or top-level predators, and therefore are potential accumulators of oceanic contaminants. Noise and shock waves generated by seismic surveys, drilling, construction, and support vessels potentially threaten all marine mammals by displacing them from otherwise dependable feeding grounds, migratory routes, and fragile nursing rookeries.

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Despite these concerns, there is little scientific data upon which to base management decisions. There have been two experimental studies on the effects of oil contact on pinnipeds and sea otters, and one on the effects of ingestion on pinnipeds. No study has been conducted on cetaceans. Thus, we continue to use intuition and information from conflicting field observations and imprecise popular news accounts.

There are nine major groups (Trichechidae, Dugongidae, Mysticeti, Odontoceti, Otariidae, Phocidae, Odobenidae, Ursidae, and Mustelidae) and more than 130 different species of marine mammals. It would not be realistic to attempt to assess the effects of oil, noise, etc., on each species or group. Data do not exist nor are they easily acquired. The animals themselves are not well enough understood, their environments and habitats undergo dynamic changes which are likely to affect their exposure to oil, and many of the animals are simply too large or otherwise unsuited for either captive or field studies.

The following research scheme (Fig. 1) is proposed to acquire some of the basic data needed to predict the effects of offshore oil development on marine mammals. It was developed by identifying potential hazards associated with each phase of offshore activity, and then establishing research needs, according to the threats perceived to be most common or most serious to marine mammal populations.

Phases of development are divided into exploration, production, and transportation, each of which has a variety of associated activities. Each activity, either through its very nature or as a result of aberrant function, generates a potential hazard, the effect of which is presumed or has been shown to be detrimental to marine mammals or their environment.

Shock Waves

Effects

Hill[1] has provided an exhaustive review of the effects of underwater

[1]Hill, S. H. 1978. A guide to the effects of underwater shock waves on Arctic marine mammals and fish. Unpubl. manuscr., 50 p. Inst. Ocean Sci., Patricia Bay, Sidney, B.C., Pac. Mar. Sci. Rep. 78-26.

ABSTRACT—The development of offshore oil and gas reserves presents a number of potential threats to marine mammals. Seismic surveys employing various high explosives can be lethal at close range. Noise is associated with all phases of petroleum exploration and production. The physical, physiological, and behavioral effects of noise disturbance on marine mammals are poorly understood and need to be investigated.

Exposure to spilled oil has been implicated as the cause of death of pinnipeds and cetaceans, however much of the evidence has been inconclusive. Surface contact is threatening to those species which rely on hair or fur for thermal insulation, such as sea otters, fur seals, and polar bears. Though cetaceans are not likely to accumulate oil on their body surfaces, the unique metabolic and physiologic properties of cetacean skin may be impaired by toxic fractions in crude oil. Marine mammals are unlikely to ingest sufficient quantities of oil to cause acute toxicity. However, the long-term effects of accumulation of petroleum fractions through the food chain are unknown. Inhalation of toxic vapors would occur in any oil spill situation, and can be life threatening in the case of prolonged exposure. The ability of marine mammals to detect and avoid oil slicks is critical to any assessment of the potential impact of oil, and yet such information is clearly lacking.

This review summarizes field observations and experimental studies of the effects of oil and oil exploration on marine mammals, identifies gaps in our knowledge, and establishes priorities for future research.

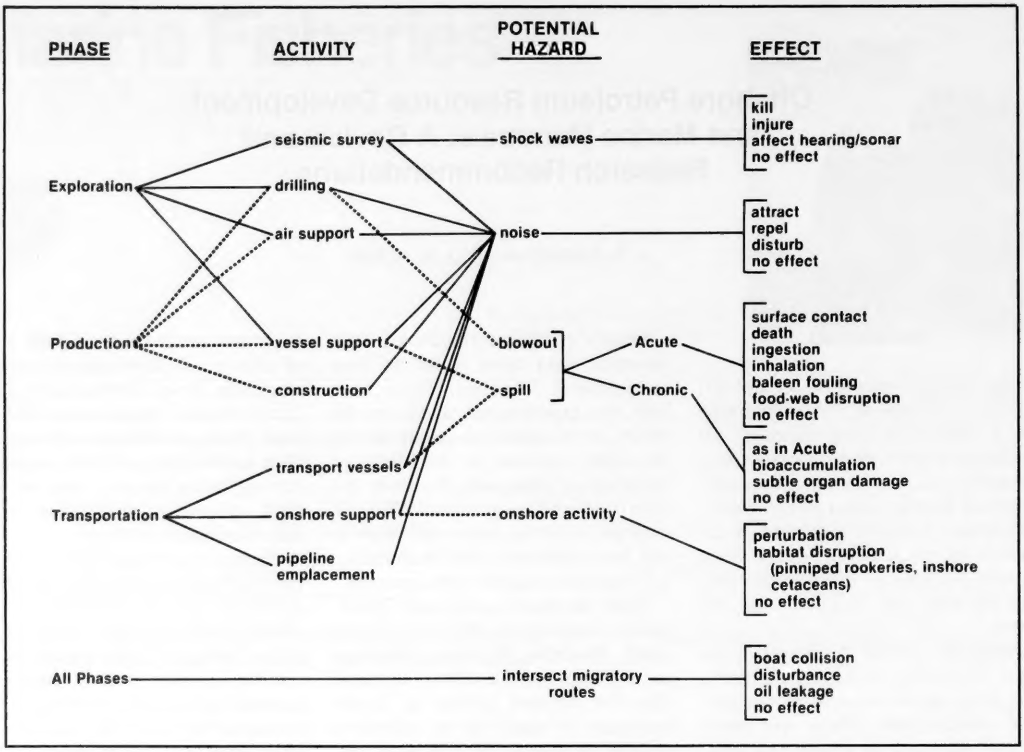

Figure 1.—Proximate factors associated with offshore oil exploration and their effects on marine mammals.

shock waves on fish, and a theoretical account of their possible effects on marine mammals. When seismic surveys are carried out at sea, sources of high-intensity sound, such as explosives and air guns, are placed directly in the water. Detonating-type or "high" explosives have been widely used. These result in a steep-fronted detonation wave which is transformed into a high-intensity pressure wave (shock wave) and an outward flow of energy in the form of water movement. There is an instantaneous rise to maximum pressure followed by an exponential pressure decrease and drop in energy.

Shock wave reflections at an interface between tissue and an air-filled cavity can cause tissue destruction at the interface. Shock waves with high peak pressures and rapid rates of change in pressure can result in damage and death to living organisms. In mammals, gas-containing organs are affected, principally lungs and hollow viscera. Animals close enough to the site of detonation can be killed (Fitch and Young, 1948).

It is possible to calculate lethal range and minimum safe distance from an explosive charge in water. A formula has been developed using fish and land animals as subjects (Yelverton et al., 1973). Its use requires knowledge of target (animal) depth, detonation depth, and charge weight. When applied to a relatively small marine mammal such as a ringed seal, *Phoca hispida*, at a depth of 25 m, minimum safe distance from a 5 kg charge detonated at a depth of 5 m is calculated to be 359 m (Hill, footnote 1). Factors influencing the calculated range include nature of the sea floor, ice cover, and water depth. For example, the calculated safe range is underestimated if the animal is in shallow water with a rocky bottom, or if the charge is detonated under thick ice.

This "safe distance" formula (Yelverton et al., 1973) was derived using relatively small land mammals and fishes as experimental subjects. No marine mammals, or animals approaching their size, have been studied. Nevertheless, Hill (footnote 1) concluded that marine mammals would be less vulnerable to damage from underwater shock waves than are land mammals of comparable size. This primarily is due to pressure adaptations and increased protection due to thick body walls. Morever, they would be further safeguarded by their large size, which in itself protects against underwater blast.

Shock waves from conventional

seismic blasts have been associated with marine mammal mortality. Fitch and Young (1948) reported that California sea lions were killed by underwater explosions used in seismic exploration; gray whales, *Eschrichtius robustus*, in the area were apparently undisturbed. Deaths also occurred in conjunction with an underground nuclear detonation on Amchitka Island in the North Pacific. Ten sea otters, *Enhydra lutris*, and four harbor seals, *P. vitulina*, were recovered dead from the beach nearest the blast site. They were considered to have been killed instantly by an estimated overpressure of 200-300 psi (14-21 bar) followed immediately by underpressure. Death was due to overwhelming destruction of virtually all organ systems (Rausch[2]).

No survey was made of areas more distant from the Amchitka test site, so that a safe distance and pressure were not established. Pressures in the zone in which mortality occurred were at least 50-70 times greater than the safe limit calculated using Yelverton's formula. Such pressures are unrealistically high in terms of those generated during conventional seismic blasting operations.

Air guns also are used in marine seismic exploration. They are placed in arrays of several guns of different sizes, and fired simultaneously. Shock waves so produced differ from those of explosives in that peak pressures are low and both the rise time of the shock pulse and the time-constant of the pressure decay are comparatively long. Shock waves so generated are harmless to fish (Falk and Lawrence[3]; Hill, footnote 1) and would not appear to be immediately injurious to marine mammals.

Recommendations

Studies should be designed to assess physiological, psychological (behavioral), and pathological effects of small graded underwater explosions on representative pinnipeds and small odontocetes, and the data extrapolated to those species or populations which are unsuitable for study, e.g., endangered species, large whales. Experiments should include an evaluation of the startle response, profiles of hearing sensitivity, morphologic assessment of cochlear sensory cells, and detailed examination of all air/tissue interfaces.

In circumstances where explosives must be detonated underwater, the following steps should be taken:

1) Using the formula from Yelverton et al. (1973), calculate the ranges at which various levels of shock wave damage to marine mammals are likely. Data on explosion depth, depth of the animals, and the weight of the charge would be derived from the actual situation at each of the blast sites.

2) Assess behavioral patterns of those species occupying, utilizing, or migrating through potential blast areas. Determine their physical vulnerability using the calculated "safe distance" formula, and behavioral response by using reasoned predictions based on known species behavior and life history.

3) Where marine mammals are considered vulnerably close to blast areas, adopt techniques to reduce potential damage: a) modify charge and arrangement of explosives (Jakosky and Jakosky, 1956); b) detonate small "scaring charge"; c) bury charges in the sea bottom (Hubbs and Rechnitzer, 1952).

Noise

Physiological Effects

Noise is associated with all phases of offshore petroleum exploration and production. It accompanies seismic surveying, drilling, air and ship support, construction, and the operation of onshore and offshore facilities.

Effects of noise on marine mammals have not been investigated. In laboratory animals, auditory damage associated with impulse noise correlates with peak level, duration, rise time, frequency spectrum, background noise level, and number or frequency of repetitions. Noise beyond a definable threshold causes degeneration of cochlear sensory cells with associated loss of hearing. The actual damage is due to the moment of inertia created by the sudden movement of the stapes. The high energy generated brings about acoustic overstimulation and this in turn causes functional sensory cell damage. If the energy is great enough, sensory cells may degenerate and, in the extreme, dislodge from the supporting cells. Such changes are morphologically detectable (Stockwell et al., 1969), but functional correlations are difficult to establish (Henderson et al., 1973).

Most of the studies on noise-associated cochlear damage have utilized high frequency sounds., e.g., ultrasonic radiation. Resulting damage is relatively easy to detect because of the basic architecture and orderly arrangements of cells and membranes in the high frequency region of the cochlea (Ramprashad et al., 1973). However, low frequency sounds of the type which are likely to emanate from activities related to petroleum exploration and production are less destructive than high frequency sounds and their effects are more elusive (Ramprashad[4]). Low frequency sounds are analyzed in the apical portion of the cochlea. This includes a wide area along the length of the basilar membrane, within which specific cell damage is difficult to localize.

The effects of noise on nonauditory physiology of birds and mammals have been reviewed by Fletcher (1971). These appear to be stress-mediated, and involve adrenergic and cholinergic responses, possibly associated with lowered resistance to disease, increased vulnerability to environmental disturbances, and endocrine imbalances which might in turn affect reproduction. Such stress-mediated effects might well apply to marine mammals. Hyponatremia in free-ranging pinnipeds (Geraci

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[2]Rausch, R. L. 1973. Post mortem findings in some marine mammals following the Cannikin test on Amchitka Island. Manuscript prepared for U.S. Atomic Energy Commission, Las Vegas, Nev., 86 p.

[3]Falk, M. R., and M. J. Lawrence. 1973. Seismic exploration: its nature and effect on fish. Fish. Mar. Serv., Winnipeg, Tech. Rep. Serv. No. CEN T-73-9, 51 p.

[4]F. G. Ramprashad, Department of Zoology, University of Guelph, Guelph, Ontario. Pers. commun. 1979.

et al., 1979) and adrenal cortical disturbances in odontocetes (Geraci et al.[5]) are conditions which may compromise the normal stress response, making affected animals more vulnerable to noise disturbance.

Behavioral/Psychological Effects

Two types of noise can be identified as potentially affecting marine mammal behavior: Impulse and chronic background noise. Impulse noise elicits a startle reflex, the characteristics of which vary with species, age, sex, and psychological status (Landis and Hunt, 1939; Moyer, 1963; Rylander et al., 1974).

The startle reflex in marine mammals has not been studied per se, but has been described through behavioral observations and anecdotal accounts. In pinnipeds, sudden disturbances cause dispersement from rookeries, often taking the form of a spontaneous mass movement, or stampede, into the water (Loughrey, 1959; Salter, 1979). This, in turn, may lead to disruption of mother-pup pair bonds and accidental injuring or killing of pups. Recolonization of the rookery may then be associated with injurious territorial aggression.

Moreover, repeated disturbances may lead to colonial pinnipeds abandoning traditional breeding areas in favor of less suitable sites. For example, underwater vocalizations of harp seals in whelping areas decreased sharply following the arrival of a vessel, but it could not be determined whether this was due to a change in behavior, or a shift in location (Terhune et al., 1979). Under most circumstances, it would seem that pinnipeds most vulnerable to the effects of noise disturbance might be perinatal females and nursing pups and calves, molting animals, and those stressed by parasitism and disease (Geraci and Smith, 1976a).

Some cetaceans respond to sudden disturbances by sounding, aggregating, or dispersing, and subsequent regrouping of the social structure (Leatherwood[6]). This is particularly true of the more gregarious odontocetes. These behaviors are adaptive and obviously designed to protect against a sudden threat. However, in some cases they may be detrimental. Some of the hypotheses used to explain mass strandings of cetaceans include acoustical confusion (Dudok van Heel, 1966), meteorological conditions (Hall et al., 1971; Stephenson, 1975), and unusual disturbances. For example, van Bree and Kristensen (1974) attributed a small mass stranding of Cuvier's beaked whales, *Ziphius cavirostris*, in the Caribbean to an underwater explosion.

Unlike the abrupt response to a sudden disturbance, most animals become habituated to low-level background noise such as would be associated with ship traffic and onshore and offshore petroleum activities. Some species with which we are familiar, e.g., humpback and gray whales, harbor and elephant seals, bottlenosed dolphins, walruses, and sea lions, seem to coexist well with human activities. Such habituation, in fact, forms the underlying basis for the success of whale watching cruises. Nevertheless, Nishiwaki and Sasao (1977) have suggested that increased ship traffic in Japanese waters had disturbed migration routes of minke whales, *Balaenoptera acutorostrata*, and Baird's beaked whales, *Berardius bairdi*.

Although the effects of noise as it might relate to oil activities are not known, the net result of any disturbance would depend upon the size and percentage of the population likely to be affected (e.g., 100 fur seals in Alaskan waters vs. 100 manatees in Florida), the ecological importance of the disturbed area (e.g., critical habitat), and the environmental and biological parameters which influence an animal's sensitivity to disturbance and stress. An additional factor which must be taken into account is the rate of recovery or recolonization by a population following a short-term disturbance, or the accommodation time in response to a prolonged disturbance.

Recommendations

Studies on the effects of noise on marine mammals must address both first and second level effects. First level effects, such as auditory damage caused by impulse noise may have an immediate impact. In this context, the question must be answered as to the effects of acoustic overstimulation on the bone conducting auditory system of pinnipeds (Ramprashad et al., 1973) and cetaceans (McCormick et al., 1970).

Marine mammals have specialized anatomical features such as distensible venous retia, dense auditory bones, a thick tympanic membrane, and a reduced ear canal (cetaceans) or one that is under voluntary control (pinnipeds). These adaptations serve to dampen the movement of the ossicular chain (McCormick et al., 1970; Ramprashad et al., 1973), particularly during diving. A study of noise effects should compare in-air and underwater audiograms of animals exposed to high intensity, variable frequency pure-tone sound (Terhune and Ronald, 1972), in order to determine any changes in hearing threshold attributed to sensory cell destruction. Precise site of damage may be confirmed histologically. These data can then be used to assess the physical-pathological impact of the noises likely to emanate from each phase of industry operation.

Most marine mammals use sound as a form of communication, or for navigation and locating prey species. Background noise may interfere with these sounds, thereby resulting in second level effects, such as social disruption and echo confusion. The immediate effects can and should be tested experimentally. However, the long-term effects can only be assessed by observation under field conditions, and might be expected to include population decline through stress-mediated disease, decreased productivity, and displacement from favorable habitats. These

[5]Geraci, J. R., S. A. Testaverde, D. St. Aubin, and T. Loop. 1976. A mass stranding of the Atlantic white-sided dolphin, Lagenorhynchus acutus: a study into pathobiology and life history. Natl. Tech. Inf. Serv., Wash., D.C., PB-289 361, 141 p.

[6]Leatherwood, S. 1977. Some preliminary impressions on the numbers and social behavior of free-swimming bottlenosed dolphin calves *Tursiops truncatus* in the northern Gulf of Mexico. *In* S. H. Ridgway and K. Benirschke (editors), Breeding dolphins, present status, suggestions for the future. Natl. Tech. Inf. Serv., Wash., D.C., PB-273 673, 29 p.

questions can best be addressed by collecting baseline behavioral and population data for a few selected species and test areas, then carefully monitoring these during all phases of oil exploration and development.

Boat Collision

Accidents associated with industrial activities can be minimized but not eliminated. Oil exploration in the regions of the outer shelf will be accompanied by ship traffic through migratory routes, and low flying aircraft in the area of the drilling platform. It should be possible to minimize disturbance to marine mammals by strategically locating onshore facilities, and by carefully planning flight paths and supply ship routes. Certain problem areas have already been identified, such as inshore and coastal Florida waters which require special consideration in order to reduce manatee mortality resulting from boat collisions, gray whale calving lagoons in Baja California, and other areas of marine mammal concentrations.

Oil

Background

Over the past 10 years, reports by the media and some scientific review articles have implicated oil fouling as the cause of death of seals, sea otters, and both small and large whales. The most noteworthy incident is that of the 1969 blowout in the Santa Barbara Channel. Accounts of the incident speculated that gray whales had died as a result of the spill. Time[7] reported the presence of a stranded dolphin with an oil-clogged blowhole and lung hemorrhage. Similar accounts involved northern elephant seals, *Mirounga angustirostris*, California sea lions, *Zalophus californianus*, and the northern fur seal, *Callorhinus ursinus*. Critical assessments of the spill did not conclusively link the marine mammal deaths with the presence of oil (Simpson and Gilmartin, 1970; Brownell, 1971; Brownell and Le Boeuf, 1971; Le Boeuf, 1971).

[7]Time, 21 February 1968, p. 21.

Reports on seals contaminated in other oil spill situations are vague. There have been two events in Alaskan coastal waters in which marine mammals, mostly hair seals (Phocidae), but including sea lions and sea otters, *E. lutris*, came into contact with oil (Anonymous, 1971a, b). No mortalities were reported in the immediate vicinity at the time of the spills. In one instance, seal hunters later observed 55 "seals" with oil-contaminated pelts, and one dead sea otter coated with oil. Associated with the second spill, "Two killer whales, one sick and one dead, were observed. Four hundred hair seals... were acting in an unusual way and had a white glazed look in their eyes.... It was not known whether the deaths of a small number of sea otters were related to the contaminant. There were no deaths among the 400 hair seals that appeared to have been affected by the contaminant but they continued to behave strangely (would not enter the water)" (Anonymous, 1971b).

During the 1967 *Torrey Canyon* spill, some seals were reported to be surfacing through oil slicks; others were found dead coated with oil (Spooner, 1967). However, precise causal relationships were not established.

Following the *Arrow* spill in 1969 at Chedabucto Bay, Nova Scotia, a small number of seals reportedly died due to suffocation caused by the plugging of vital orifices with Bunker "C", a highly viscous, refined oil (Canada Ministry of Transport, 1970). Details of these observations are not available and so the account cannot be assessed critically. In another report of a Bunker "C" spill in the Gulf of St. Lawrence, 500-2,000 harp seals, *P. groenlandica*, were observed coated with oil. Some dead seals were found but it could not be determined whether oil was the causal agent (Warner[8]).

Davis and Anderson (1976) studied differences between oiled and uncontaminated gray seals, *Halichoerus grypus*, off the west coast of Wales following an oil spill of undetermined origin. Of 25 oiled pups examined, 5 (20 percent) were dead on the beach, compared with 11 of 37 unoiled pups (30 percent). Six of the dead oiled pups submitted for postmortem examination showed no evidence of having ingested oil, supporting the investigators' conclusion that "... oiling was not a direct cause of death. ... The only deaths which could be attributed directly to oil, were those of two pups, encased in oil so that they were unable to swim and thus were drowned when washed off the beach."

As recently as April 1979, following the breakup of the tanker *Kurdestan* off the south coast of Nova Scotia, as many as 14 dead and dying phocid seals (species unidentified) were observed coated with Bunker "C" oil, which was also found fouling the shoreline (Marston[9]). Detailed necropsies were not performed and, once again, the association of oil with mortality is unsubstantiated.

Oil Detection and Avoidance

Marine mammals may or may not be able to detect oil, and if so, avoid it. Yet such behavioral response is the heart of the issue. The preceding scenarios, which are by no means conclusive, show that in some cases pinnipeds and sea otters do not avoid oil whereas a cetacean has yet to be found coated with oil. The difference may be due to sensory capabilities which are more sophisticated at long range in odontocetes (Norris, 1969), perhaps enabling them to detect oil more readily. Alternately, cetacean skin is smooth and cannot accumulate oil, and unlike pinnipeds which come ashore with obvious evidence of oil, an oil-fouled odontocete may go unnoticed. In support of the latter, mysticetes have no known sonar capability (Eberhardt and Evans, 1962; Beamish, 1977), and yet have not been observed with any evidence of oil fouling.

Certain features of pinniped and sea

[8]Warner, R. E. 1969. Environmental effects of oil pollution in Canada. An evaluation of problems and research needs. Can. Wildl. Serv. Manuscr. Rep., p. 16-17.

[9]D. F. Marston, Nova Scotia Society for the Prevention of Cruelty to Animals, Halifax, Nova Scotia. Pers. commun. 1979.

otter life history may increase their vulnerability to oil. During pupping, moulting, and mating activities, their dependency on substrate may force them into repeated exposure to shoreline accumulations of oil (Davis and Anderson, 1976), despite some evidence that they are able to detect it. For example, Barabash-Nikiforov et al. (1947) reported that Japanese poachers used petroleum products to repel otters from shore rocks. The repellant effect was presumably due to repugnant petroleum odors.

Laboratory studies have not helped to resolve the question, nor can they go further than simply establishing detection capability. In the only such study to date, Williams[10] concluded that sea otters would not avoid an oil spill, but he could not determine whether the stresses of captivity and confinement were responsible for the behavior.

It is conceivable that some marine mammals may even be attracted to a spill to feed on fish and other organisms debilitated or killed by the oil. Beck (in Hill, footnote 1) observed a gray seal, *H. grypus*, feeding on injured fish in the vicinity of a shipwreck where large underwater charges were being detonated.

Recommendations

Studies should be designed to assess behavioral responses to oil. Can marine mammals detect oil? What are the sonar-echo characteristics of oil on the surface and in the water column? What is the visual response to oil? What are the limits of detection? What is the olfactory response to oil by various species? Is oiled food palatable?

Many of these questions regarding sensory perception can best be approached by experimentation under controlled laboratory conditions. However, these data must be integrated with observational data acquired during actual oil spill situations. Such events not only provide a basis for assessing the relevance of in vitro and laboratory or captivity studies, but also represent situations which cannot be experimentally duplicated.

To maximize the information yield from an otherwise disruptive ecological event, an observer team response should be organized specifically to investigate the impact of accidentally occurring oil spills, recording such factors as dispersal of oil through specific marine mammal habitat areas, e.g., rookeries, breeding or calving lagoons, as well as avoidance, feeding, reproduction, migration, and hauling-out behavior.

Behavioral Effects

The behavioral consequences of oil fouling have been noted only for pinnipeds. Kooyman et al.[11] attempted unsuccessfully to determine diving and feeding behavior in oil-fouled northern fur seals. Davis and Anderson (1976) noted reduced growth rate in oiled gray seal pups, but could not determine changes in nursing behavior as a result of oiling. Experimentally oiled sea otters spent "75% of their time underwater trying to clean their pelage" (Williams, footnote 10). Ringed seals immersed in seawater covered with light crude oil showed variable signs of irritability and increased aggression (Geraci and Smith, 1976b). When on the surface, the seals showed varying degrees of arching of the back, a behavior that was not observed in the control group or in the experimental group prior to oiling. Four days after being removed from the 24-hour oil exposure, the seals showed no behavioral or physical signs of having been oiled.

Recommendations

Critical gaps exist in our knowledge of the behavioral effects of oil fouling, and yet behavioral modifications as a result of oil contact may represent a significant impact on marine mammal populations. Changes in activities such as feeding, diving ability, mother-pup interaction, herd organization, and haul-out behavior may have immediate consequences affecting the survival of oil-fouled animals. Behavioral observations at the site of an oil spill are needed, therefore, to properly assess the effects of oil. For many species, such data are not easily interpreted due to the lack of baseline behavioral studies. Nevertheless, an accidental oil spill presents an opportunity for observations which for the most part cannot be duplicated under laboratory or captive conditions, and data so collected will be available for retrospective analysis following cleanup and restoration of the oil-fouled area.

Thermal Effects

Recent experiments have addressed some potential oil effects on thermoregulation in pinnipeds and sea otters. Kooyman et al. (1977, footnote 11) investigated the effects of oiling on thermal conductance of pelts from sea otters and four species of otariid and phocid seals. Most affected were pelts from a sea otter pup and two subadult northern fur seals in which conductance doubled. No change was noted in a California sea lion, and bearded seal, *Erignathus barbatus*, pelts. An oiled Weddell seal, *Leptonychotes weddelli*, pelt showed an intermediate increase in conductance. Control values for phocid seal and sea lion skins were high. The investigators concluded that fouling of fur in sea otters and fur seals would have serious consequences and, if the insulative properties of the pelts were not restored through grooming, these species probably could not endure prolonged immersion in cold water.

In an unrelated and less convincing study, two sea otters were placed in a holding pen in which Alaska crude oil covered one-half of the surface (Williams, footnote 10). One otter was removed to a clean holding pen, and was found dead 9 hours later. Williams (footnote 10) speculated that the animal had died of hypothermia. His conclusion is not supported by physiological or pathological data, but seems reasonable based on the Kooyman et al. (1977, footnote 11) studies.

[10]Williams, T. D. 1978. Chemical immobilization, baseline hematological parameters and oil contamination in the sea otter. U.S. Marine Mammal Commission Report MMC-77/06, 27 p. Natl. Tech. Inf. Serv., Springfield, Va.

[11]Kooyman, G. L., R. L. Gentry, and W. B. McAllister. 1976. Physiological impact of oil on pinnipeds. Processed rep., 23 p. Northwest Fisheries Center, Natl. Mar. Fish. Serv., NOAA, Seattle, Wash.

Studies were conducted on ringed seals, *P. hispida*, immersed in seawater covered with light crude oil for 24 hours and on newly weaned harp seal pups, *P. groenlandica*, coated with crude oil for 7 days (Smith and Geraci, 1975). In all cases, body temperatures remained stable within the normal range. In vitro examination of the pelts from these studies showed that thermal conductance was not changed as a result of oil. The major effect on the fur was to increase solar heating capacity.

Recommendations

All evidence indicates that animals which rely on hair or fur for thermal insulation will be adversely affected by surface contact with oil. By experimentation and extrapolation, we may consider sea otters, fur seals, and polar bears in this category. Phocid seals are more resistant to the thermal effects of oil, likely due to their reliance on blubber and vascular mechanisms for thermal insulation. Cetaceans would be similarly resistant to mechanical interference with thermoregulation, particularly because the smooth body surface would substantially reduce the likelihood of physical fouling by even the heavier adhesive fractions. Further studies on thermal effects of surface fouling should therefore be afforded low priority.

A study directed toward testing various solvent-emulsifiers which might be used to clean oiled marine mammals would also be considered low priority. Application of such techniques in the field are impractical, not likely to reduce mortality significantly, and in fact may be detrimental as a result of excessive handling (Davis and Anderson, 1976) or interference with natural oils on the fur (Williams, footnote 10).

Noxious Effects

Some anticipated effects of surface contact with oil are irritation and inflammation of eyes, skin, and sensitive mucous membranes. The nature of the damage has been adequately demonstrated in ringed seals immersed in oil-covered seawater (Geraci and Smith, 1976b). Seven or eight minutes after oiling, one of the seals began to lacrimate excessively, and would frequently open and close its eyes. Soon eye irritation became apparent in the other seals. They lacrimated profusely, yet at first there was no attempt to close their eyes to avoid the oil. Twenty minutes into the study, however, some of the seals seemed to have difficulty keeping their eyes open; the conjuctiva of the eyes were obviously reddened and inflamed. Within 4 hours, all of the seals were lacrimating and squinting.

After 24 hours of exposure, examination of the eyes revealed severe conjunctivitis, swollen nictitating membranes, and evidence of corneal erosions and ulcers. Within 3 hours of being placed in a clean seawater pen, most of the eye squinting and lacrimation had subsided, and by 20 hours, the eyes showed no signs of irritation.

There were no other surface effects noted in the immersed seals, nor have skin lesions been unequivocally linked with accidental or experimental exposure to oil. Although oil-fouled cetaceans have not been observed, the nature of their skins suggests that they may be particularly vulnerable to the noxious effects of surface contact with oil.

Cetacean epidermis is a unique organ, having no counterpart in other mammals (Ling, 1974). The outermost layer is not keratinized, but consists of flattened viable cells with elongated nuclei and prominent organelles, including mitochondria. The epidermal cells are rich in enzymes creatine kinase, sorbitol dehydrogenase, and aspartate aminotransferase (Geraci and St. Aubin, 1979). These enzymes are respectively involved with high energy phosphate conversion, hexose metabolism, and transamination of amino acids. Cetacean epidermis is also rich in vitamin C (St. Aubin and Geraci, in press), the antioxidant properties of which may serve to protect the enzymatically active intracellular environment.

These findings support other biochemical evidence of high metabolic activity (Tinyakov et al., 1973; Dargoltz et al., 1978) but as yet the reason or reasons for this activity is not understood. Nevertheless, physical or chemical disruption might be expected to have immediate and far-reaching metabolic consequences, perhaps affecting vital ionic regulation and water balance. Cetacean skin is virtually unshielded from the environment, and it may respond to noxious substances such as oil in a manner approaching sensitive mucous membranes.

Recommendations

The irritating properties of oil on the ocular and periocular tissues were well documented in the ringed seal immersion experiment (Geraci and Smith, 1976b). By reasoned interpretation, we can predict that petroleum hydrocarbons will be similarly harmful to other marine mammal species. As such, a study to quantify ocular damage as a result of oil contact would appear unnecessary.

Experiments to determine the noxious effects of oil contact on cetacean skin should be given high priority. The morphologic and metabolic nature of cetacean epidermis demands that biochemical and physiological studies rather than physical-thermal studies be carried out to assess the effects of oil contact. Such studies should also include an assessment of the effects of dispersant-treated oils, as these will likely be contacted by marine mammals during oil clean-up operations.

Ingestion and Accumulation

Marine mammals exposed to a spill may ingest and accumulate oil. Ingestion might occur incidental to surface activities, in association with surface feeding in the case of large whales, or with grooming in sea otters. A less direct route of accumulation might be through feeding on contaminated prey species.

It is also conceivable that ingested oil could foul baleen plates. Crude oils are complex mixtures of hydrocarbons. Lighter fractions evaporate quickly, so that crude oil density and viscosity increase with weathering. The heavier weathered fractions, as well as heavy refined products such as Bunker "C", presumably would present the most serious threat with regard to possible baleen fouling in surface feeding whales. The threat probably would di-

minish dramatically with time as the oils disperse. Raw crude oil or lighter oil fractions might have quite a different effect. Although they may have less fouling potential, they are volatile and destructive to tissue, and might thereby damage the structural integrity of the baleen plates or horny tubes that compose the food-filtration mechanism.

Ingested oil is potentially toxic. Acute cytotoxic damage, associated with low molecular weight volatile fractions, has been observed in most animal species which have been studied, while more subtle organ damage may be associated with repreated ingestion of less volatile fractions (Moore and Dwyer, 1974).

In testing acute toxicity of ingested oil to marine mammals, Geraci and Smith (1976a) performed a series of experiments on phocid seals. They found that ringed seals rapidly absorbed crude oil hydrocarbons into body tissues and fluids, ultimately excreting the compounds via bile and urine (Engelhardt et al., 1977). Harp seals given up to 75 ml of crude oil, far in excess of that calculated to have been swallowed by the ringed seals immersed in oil-covered water for 24 hours, showed no clinical, biochemical, or morphological evidence of tissue damage (Geraci and Smith, 1976a).

Thus, relatively large quantities of oil accidentally ingested over a short period of time were not associated with acute organ damage. These findings cannot be extrapolated to greater quantities of oil or to other groups of marine mammals. Yet the findings from these studies tend to dampen the fear that accidental oil ingestion associated with feeding would be necessarily harmful to carnivorous marine mammals. Sirenia, on the other hand, might respond quite differently. They are herbivores, and ingestion of oil-contaminated food might be expected to harm the gut flora or interfere with secretory activity of the gastric glands (Kenchington, 1972), thus affecting digestion and perhaps survival.

Any study on oil ingestion must address long-term effects associated with fractions persistent in the food chain. Benthic invertebrates accumulate aromatic hydrocarbons in varying degrees, both from seawater (Stegeman and Teal, 1973), and from bottom sediments (Roesijadi et al., 1978). In the soft-shell clam, *Mya arenaria*, maximum tissue levels are attained within 1 week (Stainken, 1978). In another deposit-feeding clam, *Macoma inguinata*, and the suspension feeding clam, *Protothaca staminea*, hydrocarbon concentrations continue to increase with exposure (Roesijadi et al., 1978).

Generally deposit feeders accumulate hydrocarbons to a greater extent than suspension feeders. Representatives of this group compose a significant portion of the walrus diet (Vibe, 1950). For this reason walruses would seem to provide a natural field model for determining effects of long-term hydrocarbon accumulation.

Levels of hydrocarbons in benthic organisms vary due to animal species, nature of the substrate, and hydrological conditions. In seven benthic invertebrates representing five phyla, hydrocarbon levels decreased after initial exposure to contaminated sediments (Grahl-Nielson et al., 1978). Yet in the case of the Chedabucto Bay oil spill off Nova Scotia, hydrocarbon levels in the soft-shell clam, *M. arenaria*, were found to exceed 200 μg/g, 6 years after the event (Gilfillan and Vandermeulen, 1978). These high tissue concentrations correlated with persistent high hydrocarbon levels in the sediment. This raises the interesting question of the possible effects that pipeline and platform construction, or other forms of physical disturbance might have on resuspending contaminated sediments, thus making them more available to benthic invertebrates and fish in critical feeding grounds for bottom feeders such as walruses, sea otters, and bearded seals.

Persistence of hydrocarbons in at least some mollusks is due to their apparent lack of the degrading enzyme aryl hydrocarbon hydroxylase (Vandermeulen and Penrose, 1978). Fish have this enzyme, and within 2 months of exposure, metabolize 98 percent of the accumulated hydrocarbon load, retaining naphthalenes and tetramethylbenzene (McCain et al., 1978), the components ultimately transferred to top level predators.

The long-term effects of ingestion of these compounds by marine mammals are unknown, but Hodgins et al. (1977), in their review of the literature, provided unequivocal evidence that certain petroleum hydrocarbons, such as benzopyrene, are potent carcinogens in a wide variety of invertebrate and vertebrate species. Although marine mammals would likely suffer the same consequences, the issue is rather academic, as any experiment designed to test the hypothesis would draw upon unrealistic circumstances of selective feeding on specific carcinogenic fractions.

More realistic, and perhaps more important to population health and stability, are the subtle and elusive effects of functional impairment of those organ systems which can be evaluated only with time, e.g., the central nervous and reproductive systems. In an historical analysis of cetacean strandings on the coast of the Netherlands, van Bree (1977) has associated two periods of sudden decline in the number of strandings to an increase in pollutant levels in the North Sea. He reported that, "The first probably took place around 1946" and there is a "...possibility that this... is linked to the dumping of war chemicals at that period or by the increase in the use of oil....[the] second decrease is clearly related to the increase of pollution of the North Sea...."

The conclusion is intriguing, and though still subject to discussion, it draws on 45 years of carefully documented observations on the frequency of strandings. If true, then it calls attention to the reason or reasons underlying the population decline, and the possible role of pollutants, including petroleum hydrocarbons, on reproductive success.

Helle et al. (1976) found that about 40 percent of a sample of Baltic ringed seal females of reproductive age showed pathological changes in the uterus, associated with unusually high levels of DDT and PCB substances. Premature parturition in California sea lions has been correlated with high tissue levels of DDT and PCB's, in association with disease agents and trace element imbal-

ances (Gilmartin et al., 1976). Data on tissue hydrocarbon burdens in free-ranging marine mammals, such as would be required to realistically interpret these findings, are not presently available.

Recommendations

Laboratory experiments should be conducted to determine the fouling properties of various crude oil fractions on baleen. These studies must address factors such as filtration rate and efficiency, structural integrity of baleen plates, and recovery time. Interpretation of the findings is complicated by a general lack of understanding of the mechanisms and characteristics of baleen feeding, but until such data are available, we must rely on extrapolation from in vitro studies. Insight into the potential problem of baleen fouling would be significantly enhanced by observations and sample collection from dead mysticetes, stranded or floating near the site of an oil spill.

Limited studies of the acute effects of ingested oil on predatory marine mammals have been done. Geraci and Smith (1976a) demonstrated that consumption of a substantial quantity of oil had no observable harmful effect on harp seals although pathological changes could no doubt have been induced by increasing the dose. In an equivalent experiment which did produce pathological changes, 10 liters of a light Texas crude oil were administered to bovine calves the same size as an adult *Tursiops* (Rowe et al., 1973). Although it would seem inappropriate to repeat this study on larger pinnipeds or cetaceans, stomach contents and tissue burdens of dead or moribund animals in the area of spills should be examined as a matter of course.

Sirenians, though conceivably more vulnerable to acute effects of oil ingestion, are unsuitable for experimentation by virtue of their reduced numbers. Dead and debilitated manatees recovered from the Florida canal systems should be utilized for studies of tissue hydrocarbons, and for in vitro effects of petroleum hydrocarbons on gastrointestinal flora and digestive enzymes.

Although ingestion studies are not required, there is a need to determine the potential for bioaccumulation of petroleum hydrocarbons in marine mammals. The problem can be attacked from another direction: By assessing the functional capacity of enzyme systems to metabolize hydrocarbons, and by analyzing for the presence of hydrocarbons and metabolites in marine mammals known or suspected to have come into contact with oil.

Studies should also be directed toward assessing the effects of long-term ingestion and accumulation of oil fractions, particularly those transferred through the food chain. Baseline data on the type and concentration of hydrocarbons in food organisms are available, and could be used for preliminary studies on conventional laboratory animals. Such experiments could not feasibly be carried out on marine mammals, due to the numbers of animals which would be required to obtain statistically meaningful data for a variety of compounds and doses.

The long-term effects of persistent hydrocarbons on marine mammal organ systems can only be addressed through continued surveillance of free-ranging animals, particularly stranded specimens. Through a monitoring program, it may be possible to relate functional or behavioral changes in marine mammals to tissue and environmental levels of hydrocarbons, such as have already been described for certain other pollutants (Gilmartin et al., 1976; Helle et al., 1976; van Bree, 1977).

Inhalation

Studies on ringed seals showed that during the 24-hour immersion in oil-covered water, some volatile hydrocarbons were likely absorbed through the respiratory tract (Geraci and Smith, 1976a). That is, tissue hydrocarbon concentrations were higher than could be accounted for by the imperceptible quantities calculated to have been swallowed (Engelhardt et al., 1977). Transient kidney and possible liver lesions were observed, but there was no associated lung pathology. The experimental setting within the confined holding pen (Smith and Geraci, 1975) provided a more concentrated exposure to volatile fractions than would normally be encountered in an oceanic spill. Thus, short-term inhalation is not necessarily harmful either in terms of structural damage or gas exchange.

Effects of prolonged inhalation have not been examined in marine mammals. However, it is likely to have the same consequences as have been observed in rats, i.e., central nervous system disturbance, bronchopneumonia, and death (Carpenter et al., 1978). Such prolonged inhalation will feature prominently in a major spill or in one in which animals tend to remain.

Some concern has been expressed over the possibility of oil clogging the cetacean blowhole. This seems unlikely as the typical breathing cycle of cetaceans involves an explosive exhalation followed by an immediate inspiration and abrupt closure of the muscular plug. This mechanism has evolved to prevent inhalation of water and would be as discriminatory of oil.

Recommendations

Experiments specifically directed at assessing inhalation effects would not yield more than can be deduced from a reasoned interpretation of existing literature on oil properties, oil effects, and marine mammal biology. Notably, the net effects of inhaled vapors will depend on the composition of oil; duration of exposure; environmental conditions affecting evaporation, dissolution, and dissipation (Cretney et al., 1978; Moore and Dwyer, 1974); and the health of the animal. It is reasonable to expect that prolonged exposure to petroleum vapors, particularly highly volative fractions, can be life threatening.

Oil Countermeasures

Oil cleaning operations are associated with unprecedented human activity, and aerial and ship traffic. Case studies of the Santa Barbara blowout and spills of the *Torrey Canyon*, the oil barge *Florida* in Buzzards Bay, Mass., *Arrow* in Chedabucto Bay, Nova Scotia, and *Argo Merchant* in Nantucket shoals show that clean-up operations are justified on the basis of the importance of coastal recreational amenities and potential damage to the fish and

shellfish industry. The mechanics of such operations at present involve activities that may have greater impacts on marine mammals than oil itself.

For example, the *Torrey Canyon* clean-up involved an initial bombing with 160,000 pounds of high explosives, 10,000 gallons of aviation kerosene, 3,000 gallons of napalm, and rockets. Subsequently, 2.5 million gallons of eight different solvent emulsifiers were used. Shore operations included burning with flamethrowers, magnesium powder, and high-temperature flares, and physical removal with the aid of heavy equipment, booms, suction devices, straw, and other absorbent material, and steam cleaning (Gill et al., 1967; Butler et al.[12]). More recent operations have been somewhat less rigorous.

Recommendations

Oil countermeasures should be dictated to some extent by the presence or proximity of marine animals. This is particularly true of areas surrounding pinniped rookeries, such as the Leeward Islands in the Hawaiian chain (monk seals) and Sable Island in the North Atlantic (gray and harbor seals), the sea otter range in California, the manatee range in Florida, and open leads occupied by migrating belugas, *Delphinapterus leucas*, and bowhead whales, *Balaena mysticetus*.

Oil countermeasures should consider the effects of solvent-emulsifiers, which may be more harmful to marine mammals than exposure to oil alone (Davis and Anderson, 1976; Williams, footnote 10). Studies should be undertaken to determine the effects of surface contact of oil/solvent-emulsifier mixtures, particularly on cetaceans.

Indirect Effects

The most noteworthy finding from the phocid seal studies was that captive ringed seals immersed in light crude oil-covered water, under similar conditions as had been carried out in the field, died within 71 minutes (Geraci and Smith, 1976a). The investigators concluded that the marked difference in results was due to the added stress of captivity in the second experiment, and that oil or another environmental stressor may have a selective effect on stressed or otherwise weakened members of a population.

In this context, marine mammals might be more vulnerable to the effects of oil when naturally stressed during moult, reproduction, times of low food availability, or when weakened by parasites and disease. For example, the effects of inhalation may be particularly harmful to inshore dwelling harbor porpoises, *Phocoena phocoena*, and harbor seals, *Phoca vitulina*, infected with debilitating lungworms and heartworms (Geraci[13]). Also vulnerable would be moulting pinnipeds in a fasting state, and cetaceans whose excursions into low salinity environments may lead to an exaggerated skin response (Harrison and Thurley, 1974).

The ultimate effects of oil will depend on the interaction of physical factors such as location, season, and weather and water conditions with biological variables associated with life history and individual and species responses to oil. Physical factors can be defined, predicted, and controlled to some extent; the biological variables are more elusive, and must be clarified through research.

A Monitoring Program

The nature and direction of research on oil effects ultimately will be influenced by field observations at the site of oil spills or blowouts. The question of detection and avoidance/attraction is critical to an understanding of potential oil impact, yet there are presently no data available on which to base management decisions. For most species, such data can only be gathered through detailed investigation of oil spill situations. Regional response teams having expertise in marine mammal behavior, ecology, and pathology should be organized to participate in oil spill task forces, and assess the impact of all phases of cleanup and recovery on marine animals.

A monitoring program should be extended to include investigation of critical habitats in advance of any oil or gas related activities. Population surveys and behavioral observations are necessary in many areas where baseline data are lacking. Interpretation of future oil impacts may be hampered by the absence of such information. Careful and consistent documentation of marine mammal strandings, with emphasis on frequency, location, and pathology, will also be critical to a proper assessment of oil-related mortality.

Background data on tissue hydrocarbon levels can be obtained from stranded animals or any marine mammals taken as part of, or incidental to, commercial fishery operations (e.g., porpoise-tuna, harp seals, northern fur seals, mysticetes trapped in fishing weirs). Pathological and toxicological findings in marine mammals recovered in or near an oil spill or from chronically polluted waters could then be more meaningfully interpreted. This approach may be the only alternative which will provide data on the effects of long-term bioaccumulation of petroleum hydrocarbons.

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A Preliminary Analysis of the Tilefish, *Lopholatilus chamaeleonticeps*, Fishery in the Mid-Atlantic Bight

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The tilefish, *Lopholatilus chamaeleonticeps*, a large demersal species of the outer continental shelf, presently supports a valuable fishery in the Mid-Atlantic Bight (Cape Cod to Cape Hatteras). In 1978 over 3,000 t (7 million pounds) worth about $4 million were landed in this area.

Tilefish and the fishery for them have an interesting and varied history. This species was first discovered in 1879 (Goode and Bean, 1880) but suffered a mass mortality, estimated conservatively at 1.5 billion fish, in 1882 (Collins, 1884) and was feared extinct just as interest was developing in a fishery for it. It was theorized that the warmer water of the continental shelf edge in which they resided was displaced by cold continental shelf water (Verrill, 1882) thus causing the mortality. Then in 1892 eight specimens were caught in several locations between south of Martha's Vineyard and the Delaware Capes (Rathbun, 1895), and they apparently increased in abundance thereafter (Bumpus, 1899).

Little is known of the biology of tilefish. Large adults may attain a maximum size of about 60 pounds, however, most fish average 5 to 20 pounds. They are known to occupy burrows in "pueblo village communities" in the vicinity of submarine canyons (Cooper and Uzman, 1977; Warme et al., 1977), where they feed primarily on crustaceans, fish, squid, and polychaete worms.[1] The remaining information on tilefish biology is summarized in Freeman and Turner,[2] and it is apparent that there is inadequate data on the life history and population dynamics to manage this species.

The purpose of this paper is to describe the commercial longline fishery in the Mid-Atlantic Bight and report preliminary results of catch and fishing effort studies.

Methods

Data on the commercial fishery was obtained in cooperation with longline fishermen from Barnegat Light, N.J. (Fig. 1). Since the spring of 1978, cooperating fishermen have maintained logs providing necessary catch information (e.g., catch, catch location, amount of gear fished, configuration of gear, and time fished). Information for earlier years was obtained from fishermen's logs and occasional notes of Steve Turner. Together these represent 86 commercial fishing trips between 1974 and the spring of 1979. It is important to note that these data provide only limited coverage of the fishery, especially for earlier years. We do not know total annual efforts nor can we extrapolate them, because we lack adequate information before 1978. However, we feel these data are sufficient to describe the fishery operating from Barnegat Light and provide useful indices to variations in effort and abundance by seasons, fishing areas, and depths. A hook

Figure 1.—A portion of the Mid-Atlantic Bight and Georges Bank showing major submarine canyon fishing areas.

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[1]Turner, S. C., and B. L. Freeman. 1978. Food habits of tilefish, *Lopholatilus chamaeleonticeps*, in the Mid-Atlantic Bight. Unpubl. manuscr., 18 p. Northeast Fisheries Center Sandy Hook Laboratory, National Marine Fisheries Service, NOAA, Highlands, NJ 07732.

[2]Freeman, B. L., and S. C. Turner. 1977. Biological and fisheries data on tilefish, *Lopholatilus chamaeleonticeps*, Goode and Bean. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Sandy Hook Lab. Tech. Ser. Rep. 5, 41 p.

was chosen as the most accurate and comparable unit of effort. Differences in catch per unit of effort (CPUE) between years, seasons, fishing areas, depth zones, and vessels were conducted using analysis of variance (ANOVA). The year-seasons and all vessel interactions were not testable due to insufficient data. All other interactions, except area-season, were deemed unimportant by ANOVA. Due to insufficient samples, data for ANOVA were grouped as follows: Seasons—spring-March through May, summer-June through August, fall and winter-September through February; depths—73-145 m (40-79 fathoms), 146-182 m (80-99 fathoms), and deeper than 183 m (100 fathoms); years—1974, 1975 and 1976, 1977 and 1978; and fishing areas—west Hudson, east Hudson, Block to Atlantis, including Middle Grounds, and Veatch Canyons. The data set for this analysis is, of necessity, based on 41 commercial fishing trips, due to the incomplete nature of some of the fishermen's logs.

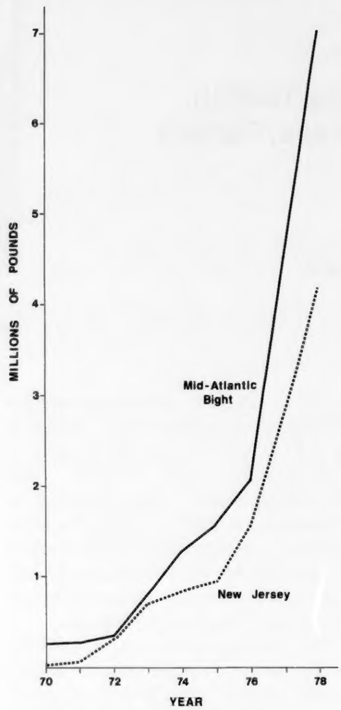

Figure 2.—Annual landings of tilefish in the Mid-Atlantic Bight and New Jersey.

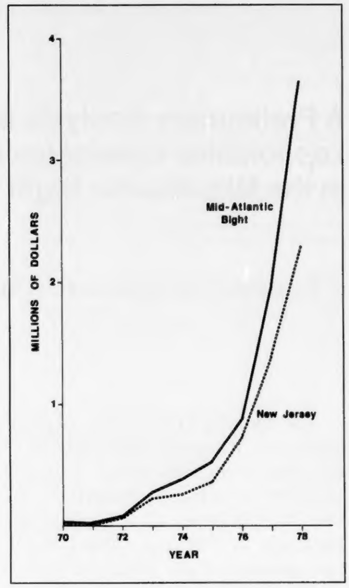

Figure 3.—Annual ex-vessel value of tilefish in the Mid-Atlantic Bight and New Jersey.

History of the Fishery

A fishery has existed for tilefish in the Mid-Atlantic Bight since 1915, and 4,500 t (10 million pounds) were landed in 10 months in 1916 (Smith, 1917). Since that time landings have fluctuated between a few hundred kilograms (thousands of pounds) and 3,300 t (7.2 million pounds) (U.S. Department of Commerce, 1979a-d). An important commerical longline fishery has developed in recent years. Since 1972 there has been a dramatic increase in commercial landings and value (Fig. 2, 3). In 1978 over 3,300 t (7.2 million pounds) worth \$3.7 million were landed in the Mid-Atlantic Bight. The catch is landed in Massachusetts, Rhode Island, New York, and New Jersey, but the latter has recently accounted for the bulk of the landings (Fig. 2, 3). This trend appears to be continuing, because New Jersey landed 1,906 t (4.2 million pounds), or 54 percent of the Mid-Atlantic total, worth \$2.3 million in 1978 (U.S. Department of Commerce, 1979b). The vast majority of this catch is landed at Barnegat Light, N.J., which is the home port for 15 of the 17 total New Jersey longline vessels (more than half of all vessels fishing for tilefish in the Mid-Atlantic Bight). By comparison, New York landed 953 t (2.1 million pounds), or 29 percent of the Mid-Atlantic total, worth \$1.1 million. Most New York landings are at Montauk, N.Y.; several of the New Jersey vessels moved there from Barnegat Light in 1978.

The recognition of tilefish in the marketplace as a high quality product is increasing as well. During the spring of 1979, ex-vessel value of tilefish reached \$1.35/pound, the highest price yet attained. Not only are the majority of fish landed in New Jersey, but the highest ex-vessel prices are available there as well. For example, Rhode Island, Massachusetts, and New York fishermen received an average price of \$0.25, \$0.30, and \$0.39/pound, respectively, in 1977, while New Jersey longliners were paid an average of \$0.49/pound (U.S. Department of Commerce, 1978a-d). This disparity was reduced in 1978 (New Jersey fishermen were paid an average \$0.55/pound, and New York and Massachusetts fishermen received \$0.51 and \$0.41), except in Rhode Island where fishermen received only \$0.21/pound for their catch (U.S. Department of Commerce, 1979a-d).

There is a small recreational headboat fishery for tilefish in New York and New Jersey. In 1978, four New Jersey vessels made approximately 12 recreational fishing trips, landing an estimated 4,500 kg (9,900 pounds). These sport fishing trips occur in late fall and early spring, between more lucrative summer fishing for nearshore species (bluefish, flounder, scup, etc.) and totally unsuitable recreational fishing conditions in winter.

Table 1.—Annual variation in the amount of longline fished per trip and catch per hook data available for 1974-78 (N = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

	1974			1975			1976			1977			1978		
Item	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Amount of longline gear fished per trip in miles (km)	20	11.5 (7.15)		6	8.7 (5.41)		21	20.9 (12.99)		25	23.2 (14.42)		14	28.7 (17.83)	
Catch per hook in pounds (kg)	15	1.3 (0.60)	0.25 (0.11)	3	2.1 (0.99)	1.2 (0.55)	7	1.4 (0.64)	1.5 (0.68)	13	1.5 (0.68)	0.6 (0.27)	14	0.7 (0.32)	0.2 (0.09)

Gear and Operations

Bottom longlines used to catch tilefish are baited with mackerel, herring, or squid and refrozen prior to departure. However, at least two or three vessels are equipped with onboard automatic baiting gear which uses fresher (thawed once) bait. Each tub contains about 0.9 km (0.5 mile) of groundline, and about every 3.7 m (12 feet) branchlines, called snoods (0.4 m or 18 inches long), are attached to the groundline. The longlines, which use 8/0 hooks, are set over the stern and retrieved by hydraulic line haulers. The longline gear is fished in sets, a set consisting of a length of gear anchored and buoyed at either end. Several sets may be made during a single fishing trip.

From 1974 to the spring of 1979, an average trip lasted 4 days, but only 2.4 days were devoted to fishing. Sets averaged 11.1 km (6.9 miles) of gear with 3.2 sets/trip which accounted for an average 30.6 km (19 miles) of gear fished per trip. During these years the average catch per mile of gear was 263 kg (580 pounds), and the average catch per trip was 4,070 kg (8,970 pounds). The average catch rate for all years, weighted equally, was 0.64 kg (1.4 pounds)/hook.

The amount of longline fished each trip has increased markedly since 1974 (Table 1), the 1978 average being 149 percent higher than the 1974 figure. This trend dramatically demonstrates the developmental nature of the fishery during these years. Seasonally, most longline (per trip) was set in summer (41 percent more than in the winter) and fall (19 percent more than winter) (Table 2). These seasonal variations may reflect that catch rates are lowest in summer and fall (see subsequent discussion), and fishermen are setting more longline in an attempt to make a good catch. No doubt generally superior weather conditions in summer and fall are also partially responsible for these seasonal trends.

Table 2.—Seasonal variation in amount of longline fished per trip, number of days fished per trip, total amount of longline fished and catch per hook data available for 1974-78 (N = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

	Fall			Winter			Spring			Summer		
Item	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Amount of longline gear fished per trip in miles (km)	17	20.1 (32.2)		10	16.9 (27)		37	17.9 (28.6)		22	23.9 (38.2)	
Number of days fished per trip	14	2.1		5	2.2		21	2.9		22	2.5	
Catch per hook in pounds (kg)	14	0.99 (0.45)	0.4 (0.18)	3	1.4 (0.64)	0.9 (0.41)	26	1.6 (0.73)	0.8 (0.36)	9	0.7 (0.32)	0.2 (0.09)
Total amount of longline fished in miles (km)		341 (546)			169 (270)			662 (1,059)			526 (842)	

Relative to fishing area, the amount of gear fished per trip increased with distance from Barnegat Light (Table 3). For example, the average amount of longline set on a trip to Atlantis Canyon (one of the more distant fishing areas from Barnegat Light) was 122 percent of that fished at west Hudson Canyon. This trend may indicate that many long distance trips were of an exploratory nature, so fishermen set large amounts of gear in search of new productive fishing grounds, or they fished more gear to make a longer trip profitable.

The length of fishing trips also varied seasonally, the longest trips occurring in spring and the shortest in the winter (Table 2). These differences perhaps reflect that more time is involved in fishing successful gear in the spring when catch rates are highest (see subsequent discussion) and trips are shorter in winter due to generally unfavorable weather conditions.

Fishing Effort, Catch, Catch Rates, and Size of Fish

Total fishing effort has undoubtedly increased since 1974. The number of vessels engaged in fishing in the Mid-Atlantic Bight has increased from 4 or 5 in 1974 to approximately 25 in 1978. Also, the fishing power of a unit of effort has probably increased since 1974 because of factors related to locating concentrations of fish. This includes such things as improved vessels, better navigation, and increased experience. In contrast to many fisheries, there have been few changes in the fishing gear itself that would affect the fishing power of a unit of effort. While the recent addition of automatic baiting machines

Table 3.—Variation in amount of longline fished per trip, number of days fished per trip, total amount of longline fished, and catch per hook at different fishing areas that are identified by their proximity to the major submarine canyons (N = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

	West Hudson Canyon			Hudson Canyon			East Hudson Canyon			Middle Grounds			Block Canyon			Atlantis Canyon			Veatch Canyon		
Item	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Number days fished per trip	23	1.8		7	2.4		13	2.5		1	1.0		2	2.5		3	3.3		8	2.8	
Amount of longline gear fished per trip in miles (km)	33	17.1 (27.4)		14	17.0 (27.2)		5	22.0 (35.2)		1	9.0 (14.4)		2	27.5 (44.0)		3	38.1 (60.9)		9	24.4 (39.0)	
Catch per hook in pounds (kg)	24	1.1 (0.49)	0.4 (0.18)	6	1.4 (0.64)	0.3 (0.14)	8	1.7 (0.77)	0.4 (0.18)		(44.0)		1	1.4 (0.47)		3	0.8 (0.36)	0.05 (0.02)	6	2.04 (0.93)	1.7 (0.77)
Total amount of longline fished in miles (km)		564 (903)			238 (381)			110 (176)			9 (14)			55 (88)			114 (183)			220 (351)	

aboard two or three vessels has reportedly produced higher catch rates due to superior bait quality, CPUE data needed to verify this is presently lacking.

Using total amount of longline fished by sampled vessels as an index to total effort, there are variations in effort by season, fishing area, and depth. Seasonally, greatest effort was in the spring (39 percent), when catch rates were highest (see subsequent discussion), and lowest in winter (10 percent) (Table 2). Low effort in winter probably reflects generally poor weather conditions. Those fishing areas nearest to the home port of Barnegat Light received the greatest effort (Table 3), the west Hudson Canyon area having 43 percent of the total. Concerning the distribution of effort relative to depth, most fishing (85 percent of total effort) occurred between 110 and 183 m (60 and 100 fathoms) (Table 4).

Some trends in CPUE are apparent, and they may reflect changes in abundance of tilefish. Seasonally, CPUE was high in spring and winter and low in summer and fall (Table 2), and these differences are statistically significant (Table 5). These fluctuations in catch rate and perhaps abundance are recognized by the fishermen (i.e., they speak of spring blitz and summer drought), are reflected in prices (i.e., highest annual ex-vessel price is always in summer when supplies are low), and are also reflected in the operation of the fishery as previously mentioned. Tilefish at or near spawning condition have been observed mid-March through mid-September (Collins, 1884; Bigelow and Schroeder, 1953; Dooley, 1978; Freeman and Turner, footnote 2). Possibly low summer and fall catch rates reflect changes in feeding behavior during spawning.

Table 4.—Variation in amount of longline fished per trip, total amount of longline fished and catch per hook by depth in meters (fathoms) for 1974-78 (N = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

	73-108 (40-59)			100-145 (60-79)			146-182 (80-99)			183-218 (100-119)			219-254 (120-139)		
Item	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Amount of longline gear fished per trip in miles (km)	1	10 (16)		12	22.3 (35.7)		22	17.8 (28.5)		3	20.0 (32.0)		3	15.7 (25.1)	
Catch per hook in pounds (kg)	1	1.9 (0.86)		15	1.2 (0.55)	1.1 (0.49)	21	1.1 (0.49)	0.5 (0.23)	3	1.3 (0.59)	0.7 (0.32)	3	2.1 (0.59)	1.01 (0.46)
Total amount of longline fished in miles (km)		10 (16)			268 (428)			392 (626)			60 (96)			47 (75)	

Catch rates also varied significantly with fishing area (Table 5). The catch rates were lowest and fishing effort highest (amount of longline fished) (Table 3) in fishing areas most accessible to Barnegat Light (west Hudson, Hudson, and east Hudson areas), while the Veatch Canyon area had the highest CPUE. Catch rates were also low in Block and Atlantis Canyon areas, but sample sizes (number of trips for which data is available) were also small. The ANOVA showed a significant interaction between area and season (Table 5). Examination of the data revealed that

Table 5.—Analysis of variance of catch-per-hook data from the longline fishery for tilefish.

Source	df	SS	MS	P
Fishing area	3	4.561	1.520	0.0001
Depth zone	2	0.606	0.303	0.549
Season	2	5.143	2.572	0.0001
Year	2	0.222	0.111	0.3179
Vessel	4	0.707	0.177	0.1406
Area-Season	2	6.513	3.257	0.0001

this interaction was due to consistently high catches at Veatch Canyon in the spring.

Catch rates are similar for most depth zones. Highest CPUE occurred at depths that received the least effort (amount of longline fished per trip) (Table 4). The deeper zone may receive less effort because fishing conditions are more difficult there (e.g., more anchor line required, increased currents, closer to shipping lanes, and more gear lost by fouling on lobster pots).

The annual CPUE has decreased over the period spanned by our data (Table 1). Highest annual CPUE was in 1975 (0.99 kg or 2.1 pounds/hook), while the lowest was 1978 at 0.32 kg (0.7 pound/hook). The ANOVA did not indicate significant differences in CPUE betwen years (Table 5). This is probably due to the unequal distribution of data for seasons and fishing area within years.

Recent decreases in size also may be the result of fishing. Length frequency distributions of tilefish from two fishing regions (Hudson Canyon and all areas north and east of Hudson Canyon to Veatch Canyon) show a decrease in modal length since 1974 for the former and 1976 for the latter (Fig. 4). Presumably the decline in modal length is the effect of fishing on lightly exploited stocks, since it has occurred concurrently with increased catches (Fig. 2) and decreased CPUE (Table 1). Interestingly, the modal length of fish collected in 1898, 16 years after the mass mortality (Bumpus 1899), is less than that for Hudson Canyon in 1974 and similar to that for both regions in 1978 (Fig. 4). Assuming that the fish collected in 1898 are representative, the smaller modal length may reflect that they had not yet recovered completely from the mass mortality of 1882.

A comparison of early catch and fishing effort data on unexploited stocks of tilefish with our limited data may offer additional insights into the present status of the stocks in the Mid-Atlantic Bight. The earliest cruise, in May 1879, had an estimated catch of 909 kg (2,000 pounds) on 1,000 hooks (0.9 kg; 2 pounds/hook) (Bumpus, 1899). In August and September 1898, large numbers of tilefish were taken by longline for the first time since the mass mortality in 1882 (Bumpus, 1899). Catch and effort data are not available for all sets made during this cruise, and some sets were deliberately made on marginal tilefish grounds. However, nine sets which landed 1,437 kg (3,162 pounds) on 4,366 hooks (0.32 kg; 0.7 pound/hook) were made under conditions we judged comparable to present conditions. Present CPUE (0.32 kg; 0.7 pound/hook in 1978) is similar to that available for 1898. However, this similarity in CPUE is hard to interpret, because in 1898 tilefish stocks may have been still recovering from the 1882 mass mortality.

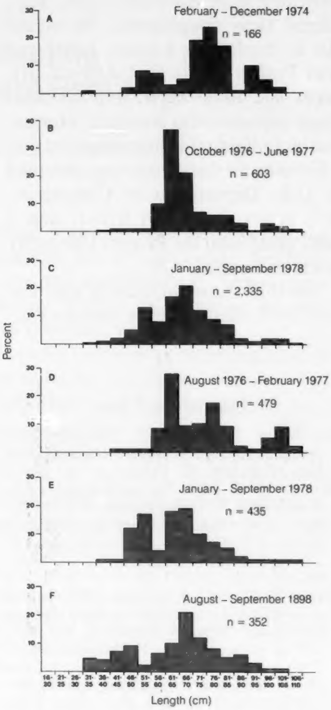

Figure 4.—Length frequencies of tilefish from Hudson Canyon (A,B,C), other fishing areas north and east of Hudson Canyon to Veatch Canyon (D,E) and from off southern New England from Bumpus (1899) (F).

Comparing the catch rates for the unexploited stocks from the May 1879 cruise (Bumpus, 1899) with data for the present fishery may be more productive. Catch rates from the 1879 cruise (0.91 kg; 2.0 pounds/hook) are similar to our spring (all years) CPUE (0.73 kg; 1.6 pounds/hook) (Table 2). If 0.91 kg/hook (2.0 pounds/hook) represents relative abundance of the unexploited stock and logistic growth is assumed for tilefish populations, then maximum sustainable yield (MSY) is at about one-half of the unexploited catch rate (Schaefer, 1954) or about 0.45 kg/hook (1.0 pound/hook). The fishery in 1978 for the same season had a catch rate of 0.31 kg/hook (0.7 pound/hook). The 1978 catch rate is lower than that at the theoretical MSY. However, because the 1898 data might not be truly representative, and the 1978 estimate is based on very preliminary data, no reliable conclusion can be drawn at this time. Additionally, analysis of catch rates may be confounded by changes in fishing power of a unit of effort. Also, this analysis treats the Mid-Atlantic Bight as a single unit, when in fact we have shown that there are significant differences between fishing areas (Table 5). Continued study may demonstrate that there are discrete populations in several areas, and planned future analyses of CPUE by these subareas may show different catch rates.

There is some evidence of a shift in fishing areas that may be related to changing catch rates. In recent years the prime fishing areas have changed from Hudson Canyon to areas farther from Barnegat Light. Exploratory fishing has extended to Georges Bank (Hydrographer, Oceanographer, and Corsair Canyons) (J. Larsen, commercial tilefish fisherman, Barnegate Light, N.J., pers. commun. 1978). These shifts may be in response to lower catch rates in more southern areas. If the fishery has moved to unexploited areas, this may maintain relatively high CPUE for the entire area but may mask local decreases in CPUE.

Catch rates for the present fishery in the Mid-Atlantic Bight are higher than

those from the Gulf of Mexico. The latter populations range from lightly exploited to unexploited, since total Gulf of Mexico landings amount to less than 80 tons (176,000 pounds) over the last 5 years (U.S. Department of Commerce 1974-79). Nelson and Carpenter (1968) reported catch rates off the Texas coast of 0.23 kg (0.5 pound/hook) and 0.11 kg (0.23 pound/hook) off Louisiana and the northern Gulf. More recent longlining off Texas yielded an overall average CPUE of 0.07 kg (0.15 pound/hook), but the catch rate was 0.36 kg (0.8 pound/hook) at the best fishing locations.[3] Comparison of these catch rates with those in the Mid-Atlantic Bight is difficult, since numerous factors other than actual abundance (fishing ability, small sampling effort, etc.) may affect the estimates.

Studies in Progress

Researchers at Rutgers University are attempting to determine if different stocks of tilefish occur along the east coast of the United States and in the Gulf of Mexico. Studies of age, growth, mortality, and reproduction of Mid-Atlantic Bight populations are being conducted as well.

Acknowledgments

We began our studies of tilefish and their fishery largely through the urgings and assistance of our friend, the late Lionel A. Walford.

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Preliminary Method for Estimating Marine Fisheries Enforcement Requirements

CHARLES M. FUSS, Jr., DANIEL W. DUNN, and ROBERT M. SPRAITZ

ABSTRACT—Standard methods are needed for estimating requirements and allocating limited resources to meet enforcement demands created by the Fishery Conservation and Management Act of 1976 and other Federal laws related to marine mammals and endangered species. The methods presented here were developed for use in the Southeast Region of the National Marine Fisheries Service. They are proposed as a first step toward the development of a more complex system. Estimates are based on the vessel population of the fishery, the fishing area, and the length of coastline fronting the fishery and/or connecting fishing ports. They include sea patrols, shore inspections, investigations, and general support.

Introduction

The Fishery Conservation and Management Act of 1976 (FCMA) and other Federal laws related to marine resources have placed new enforcement requirements on the U.S. Coast Guard, the National Marine Fisheries Service (NMFS), and State conservation agencies that have entered into cooperative enforcement agreements with the Federal agencies. Among other things, the FCMA established the U.S. Fishery Conservation Zone (FCZ) and Regional Fishery Management Councils to prepare Fishery Management Plans (FMP's). At present, approximately 76 FMP's have been identified by the Regional Councils for implementation during the next few years. Most of these plans are for domestic fisheries which have historically been managed by the individual coastal states.

One of the immediate problems facing the enforcement agencies is the development of standard systems to estimate requirements and/or allocate available resources to ensure compliance with the many regulations. The initial system should be as simple as possible but accommodate the main numerical variables (e.g., vessel populations, lengths of shoreline fronting the fisheries, fishing areas, etc.) and allow for inclusion of other quantitative variables as experience indicates. The preliminary methods described here were developed by the Law Enforcement Division of the Southeast Region, NMFS, to estimate the enforcement needs of the region. Other systems to measure enforcement efficiency, effectiveness, and quality similar to those proposed by Hirsch and Riccio (1974) will be necessary to evaluate programs and verify the initial enforcement allocations.

Regulatory Mechanism

Traditional and accepted regulatory mechanisms to prevent the depletion of marine resources have been discussed by many authors (Christy and Scott, 1965; Robinson and Rollins, 1971; and others). Controls are essentially related to fishing gear and fishing effort and may include restrictions on the type and size of gear, materials used in the construction of gear, areas and times of fishing, size or condition of species taken, and the allowable catch. Other types of regulations are related to licenses, permits, and reporting procedures such as those currently required of foreign vessels fishing in the FCZ.

In estimating the requirements for fisheries scheduled for regulations, the planner may have limited information on the kinds of regulations that will eventually be promulgated. Planners will, however, have relatively good information on the vessel population of the fishery, the size of the fishing area, the length of the coastline fronting the fishery and/or connecting the major fishing ports, the number of ports and fish processing facilities, and the fishing season. Preliminary enforcement plans must therefore be based on available data.

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Regulatory Modes

Certain fishery regulations can be enforced primarily at the dock and others must be enforced at sea. The enforcement modes used will therefore depend on the regulations. Those that can generally be enforced at the dock include catch quotas, size and condition limits, permit and reporting requirements, and some fishing gear restrictions (Fig. 1). Regulations that must be enforced at sea from patrol vessels and aircraft are those pertaining to closed areas, seasons, and some gear restrictions. Certain gear and possession regulations can only be enforced by boardings at sea from patrol vessels (Fig. 2).

Preliminary enforcement estimates should address three modes: 1) Primarily shore-side enforcement (80 percent shore and 20 percent sea); 2) balanced shore and sea enforcement (50 percent shore and 50 percent sea); and 3) primarily at-sea enforcement (80 percent sea and 20 percent shore) to allow for the various types of possible regulations. Regular enforcement duties must also be supported by special investigative techniques to ensure compliance with any regulatory mechanism.

Methods

The proposed methods for estimating enforcement requirements are based on one possible enforcement contact (boarding and inspection at sea or at the dock) with each vessel in the fishery during the fishing season or fishing year. One enforcement contact a season or year is believed to be a reasonable level of effort in newly regulated fisheries of the southeastern United States. The vessel population is thus the primary factor in preliminary enforcement estimates. Other variables considered are the fishing area and the length of the coast fronting the fishery. The

length of the fishing season is used to prorate the required enforcement activities on a monthly basis.

At-Sea Enforcement

Patrol vessel requirements are based on the assumption that a unit can accomplish an average of six vessel boardings during a 12-hour day and visually search 600 square miles of ocean. Six hours are allowed for boardings and 6 hours for searching at an average speed of 10 knots with an effective visual observation range of 5 miles on each side of the patrol track. For each hour steamed at 10 knots the patrol vessel will roughly cover 100 square miles. The average patrol day selected is the median from the probable combinations of boarding and search time shown in Table 1.

The patrol vessel's track will be affected by fishing vessel density in the area searched as shown in Figure 3. A vessel density equal to or greater than 1 vessel per 100 square miles ($\geq$0.01 vessel per square mile) will probably require the patrol vessel to deviate considerably from track and reduce the area searched. Under such conditions, patrol vessel requirements will be a function of the number of vessels only and area need not be considered. When fishing vessel density is less than one vessel per 100 square miles ($<$0.01 vessel per square mile) patrol vessel requirements will be a function of area as well as number of vessels.

Estimates of vessel density (VD) can be obtained by dividing the vessel population (VP) of the fishery adjusted for

Figure 1.—State officer inspects catch at dock for compliance with regulations. Florida Marine Patrol photograph.

Figure 2.—Coast Guard unit boarding fishing vessel during general enforcement patrol. U.S. Coast Guard photograph.

Table 1.—Probable combinations of at-sea boardings and areas searched during a 12-hour patrol vessel day (5-mile visual search range each side of track).

Vessels boarded (1 h/boarding)	Hours searched (speed 10 knots)	Area searched (square miles)
0	12	1,200
1	11	1,100
2	10	1,000
3	9	900
4	8	800
5	7	700
6	6	[1]600
7	5	500
8	4	400
9	3	300
10	2	200
11	1	100
12	0	0

[1]Median.

the enforcement mode (EM) (percent at-sea enforcement) by the fishing area (FA):

$$VD = \frac{VP \times EM}{FA}. \qquad (1)$$

If the quotient is equal to or greater than 0.01 vessel per square mile ($\geqslant 1$ vessel per 100 square miles), estimates of patrol days required (PDR) may be obtained by dividing the vessel population adjusted for the enforcement mode by six probable boardings a day (the median of probable boarding in an average patrol day):

$$\text{PDR} = \frac{VP \times EM}{6}. \qquad (2)$$

If the quotient of Equation (1) is less than 0.01 (<1 vessel per 100 square miles), PDR estimates may be derived by dividing the adjusted vessel population by 12 possible boardings a day (days required for boardings) and the fishing area by 1,200 possible square miles searched per day (days required for search) and adding the quotients:

$$\text{PDR} = \frac{VP \times EM}{12} + \frac{FA}{1{,}200}. \qquad (3)$$

Equations (1), (2), and (3) can be combined into a single equation (4) based on the average patrol vessel day (six probable boardings and 600 square miles searched with a ratio of one boarding to 100 square miles) that will eliminate the vessel density calculations. To estimate the patrol days required, divide the adjusted vessel population by six probable boardings per day and the fishing area in excess of 100 times the adjusted vessel population by 1,200 square miles (maximum area searched with no boardings) and add the quotients. Do not use negative numbers in the second part of the equation (excess fishing area) as they will cancel out any additional patrol days required. The recommended equation is:

$$PDR = \frac{VP \times EM}{6} + \frac{FA - [100 \times (VP \times EM)]}{1{,}200}. \qquad (4)$$

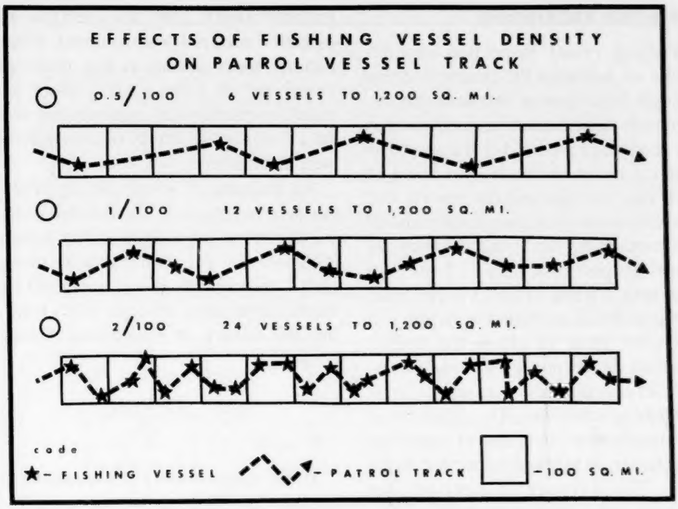

Figure 3.—Methods of estimating sea patrol requirements must allow tor deviations from patrol track caused by vessel density.

To estimate the patrol days required (or desired) for each month of the fishing season divide the total number of patrol days needed to accomplish the necessary boardings at sea by the number of months in the fishing season.

Staff years of enforcement officer (enforcement specialist in addition to patrol vessel complement) effort required for sea patrols was explained in a previous joint study by the U.S. Coast Guard and the National Marine Fisheries Service to estimate the enforcement requirements for extended jurisdiction under FCMA[1]. The study was directed entirely toward estimating the requirements to ensure compliance by foreign vessels with FCMA regulations in the FCZ. Enforcement officer requirements were based on the assumption that one officer would be necessary for each 60 days of patrol. There is no reason to change this assumption and it is applied here. The total days derived from the patrol days required equation is divided by 60 to determine officer staff years.

Patrol aircraft requirements are considered as a supplement to patrol vessel requirements. In initial regulatory programs patrol aircraft should be used to locate fishing vessel concentrations for surface patrols and for independent patrols over closed areas and/or during closed seasons to identify violators. Aircraft patrols are remote from the fishermen and therefore do not have the impact of surface patrols with boardings and inspections. They do, however, greatly facilitate the efficiency of surface patrols and should be used for that purpose as much as possible. A reasonable estimate of required aircraft patrol hours is 1 hour for each patrol vessel day to assist the surface patrols in locating target vessels. Enforcement officer requirements for aircraft patrols are included in the estimates for vessel patrols.

[1]For a complete report, see Knapp, R. J., and M. M. Pallozzi. 1977. Initial joint NMFS/CG program for enforcement of fishery regulations under extended jurisdication. Unpubl. rep., 145 p. National Marine Fisheries Service, Law Enforcement Division, Washington, D.C.

Shore-Side Enforcement

Fishing vessel inspection requirements are based on the assumption that a single enforcement inspector can accomplish three vessel inspections during an average 8-hour day and search 30 baseline miles of coast. Two hours of each day are allowed for reports and miscellaneous (including inspections of fish processing facilities), 3 hours for vessel inspections, and 3 hours for searching at a rate of 10 miles per hour. The search rate is limited to 10 miles of coast per hour to allow for traffic, coastline deviations in bays and coves, difficult access roads to vessel landings, and fishing schedules. The ratio of vessel inspections to miles of coastline searched in an average inspection day is 1:10. The average inspection day selected is the median from the probable combinations of inspection and search time shown in Table 2.

The inspection vehicle track and search rate are affected by fishing vessel density but not in the same way as patrol vessel track deviations (such as those described in the sea patrol estimates). Vessels may well be concentrated in a few ports and the inspection track (coastline) is relatively fixed. The probability, however, of locating the desired vessels in a particular port on a given day seems remote due to fishing schedules. The greater the number of vessels to be located (more vessels per given coastline) would compound the problem. Given a vessel density equal to or greater than one vessel per 10 miles of coastline (≥ 0.1 vessel per mile) the inspection day requirements will be primarily a function of the number of vessels to be inspected adjusted for the enforcement mode (percent shore-side enforcement) and the length of coastline need not be considered. When fishing vessel density is less than one vessel per 10 miles (<0.1 vessel per mile), inspection day requirements will be a function of length of coastline as well as number of vessels.

An estimate of vessel density (VD') (vessels/mile) can be obtained by dividing the vessel population of the fishery adjusted for the enforcement mode (EM') (percent shore enforcement) by the baseline miles of coast (CL) fronting the fishery or connecting fishing ports:

$$VD' = \frac{VP \times EM'}{CL}. \quad (5)$$

If the quotient (VD') is equal to or greater than 0.1 vessel per coastline mile (one vessel per 10 miles), estimates of inspection days required (IDR) may be obtained by dividing the vessel population adjusted for the enforcement mode by three probable inspections a day (the median of probable inspections in an average inspection day):

$$\text{IDR} = \frac{VP \times EM'}{3}. \quad (6)$$

If VD' is less than 0.1 (<1 vessel per 10 miles), IDR estimates may be calculated by dividing the adjusted vessel population by six possible inspections a day (days required for inspections) and the length of coastline by 60 possible miles searched per day (days required for search) and adding the quotients:

$$\text{IDR} = \frac{VP \times EM'}{6} + \frac{CL}{60}. \quad (7)$$

As with sea patrol estimates, Equations (5), (6), and (7) can be combined into a single equation based on the average inspection day (three probable inspections and 30 miles searched with a ratio of one inspection per 10 miles) that will eliminate the vessel density calculations. To estimate the inspection days required, divide the adjusted vessel population by three probable boardings a day and the coastline in excess of 10 times the adjusted vessel population by 60 miles (maximum miles searched with no inspections) and add the quotients. Do not use negative numbers in the second part of the equation (excess coastline) as they will cancel out any additional inspection days required. The recommended equation is:

$$IDR = \frac{VP \times EM}{3} + \frac{CL - [10 \times (VP \times EM)]}{60}. \quad (8)$$

To estimate the inspection days required (or desired) for each month of the fishing season divide the total number of inspection days needed to accomplish the necessary inspections by the number of months in the fishing season.

For estimates of staff years of effort required for inspections we may assume that one inspector will be available for approximately 220 working days a year (allowing for weekends, holidays, and annual/sick leave). To estimate inspector years required for shore-side enforcement the total inspection days derived should be divided by 220.

Investigations

Patrol and inspection functions will identify areas of high violation potential and provide leads that will require in-depth investigations of individuals believed to be violating regulations intentionally. These efforts should be conducted by enforcement agents trained in after-the-fact investigative techniques and equipped with the necessary tools. Quantitative factors will not be available to the enforcement planner in making preliminary estimates of investigative requirements. Such estimates can be based on requirements for sea patrols and shore-side inspections for each fishery. Past experience (NMFS Southeast Region) with domestic marine mammal and endangered species enforcement programs indicates that investigative requirements are about 30 percent of the total staff years necessary for overt patrols and inspections.

Table 2.—Probable combinations of shore-side vessel inspections and coastline searched during an 8-hour inspection day (allowing 2 hours for reports and miscellaneous).

Vessels inspected (1 h/inspection)	Hours searched (10 miles/hour)	Coastline searched (baseline miles)
0	6	60
1	5	50
2	4	40
3	3	[1]30
4	2	20
5	1	10
6	0	0

[1]Median.

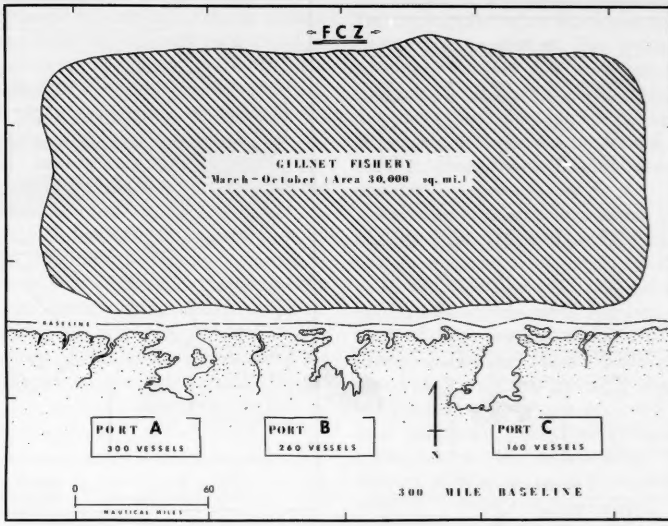

Figure 4.—A hypothetical gillnet fishery scheduled for regulation.

Support

As used here, support functions include the coordination of enforcement activities (patrol, inspection, and investigative), the development of plans, data processing and retrieval, review of violation case reports for trials and hearings, and clerical support. These are necessary to ensure efficiency, effectiveness, and quality of coordinated enforcement activities. Past experience with foreign and domestic fishery enforcement programs indicates that support requirements are about 10 percent of the total staff years necessary for patrols, inspections, and investigations.

Single Fishery Estimates

A hypothetical gillnet fishery is shown in Figure 4. We can estimate sea enforcement requirements from the factors given: $VP=720$ and $FA=30{,}000$. Using Equation (4) and an at-sea enforcement mode of 20 percent, we find:

$$\frac{720\text{X}0.20}{6}+\frac{30{,}000-[100\text{X}(720\text{X}0.20)]}{1{,}200}=37\,PDR.$$

Again, using Equation (4) with an at-sea enforcement mode of 50 percent, we find:

$$\frac{720\text{X}0.50}{6}+\frac{30{,}000-[100\text{X}(720\text{X}0.50)]}{1{,}200}=60\,PDR.$$

Finally, calculating *PDR* with an 80 percent at-sea enforcement mode, we get:

$$\frac{720\text{X}0.80}{6}+\frac{30{,}000-[100\text{X}(720\text{X}0.80)]}{1{,}200}=96\,PDR.$$

In the 20 percent enforcement mode, the fishing area (30,000 square miles) is greater than 100 times the vessel population adjusted for the enforcement mode. Therefore 13 additional patrol days are required to cover the area. In the 50 percent and 80 percent enforcement modes the fishing area is less than 100 times the adjusted vessel populations and no additional patrol days are required.

Using Equation (8), we can also estimate the shore-side enforcement requirements for the hypothetical gillnet fishery from the factors given ($VP=720$, $CL=300$, and $EM=20$ percent):

$$\frac{720\text{X}0.20}{3}+\frac{300-[10\text{X}(720\text{X}0.20)]}{60}=48\,IDR.$$

In this example the coastline is less than 10 times the adjusted vessel population and no additional inspection days are required to cover the coast. The remainder of the calculations for shore-side enforcement, investigations (30 percent), support (10 percent), and total staff years required are shown in Table 3.

Multiple Fishery Estimates

When the coastline and/or fishing areas are common to two or more fisheries the estimated enforcement requirements may be calculated from the combined fishing areas and the common coastline. This may eliminate additional patrol vessel days required to cover fishing areas that exceed 100 times the adjusted vessel population and inspection days required to cover coastlines that are greater than 10 times the adjusted vessel population.

Hypothetical purse seine and trawl fisheries with a common coastline and partly common fishing areas are shown in Figure 5. Using an enforcement

Table 3.—Summary of enforcement estimates for the hypothetical gillnet fishery shown in Figure 4.

Sea Patrols

Enf. mode[1]	Vessel population	Percent enf.	Boardings required	Patrol days	Officers required
I	720	80	576	96	1.6
II	720	50	360	60	1.0
III	720	20	144	37	0.6

Shore Inspections

Enf. mode	Vessel population	Percent enf.	Inspections required	Inspection days	Inspectors required
I	720	20	144	48	0.2
II	720	50	360	120	0.6
III	720	80	576	192	0.9

Investigations

Enf. mode	Sea officers	Shore inspectors	Total sea/shore	Agents required
I	1.6	0.2	1.8	0.6
II	1.0	0.6	1.6	0.5
III	0.6	0.9	1.5	0.5

Support and total

Enf. mode	Field enf. required	Support required	Total staff years
I	2.4	0.2	2.6
II	2.1	0.2	2.3
III	2.0	0.2	2.2

[1]Enforcement modes: I—80 percent sea, 20 percent shore; II—50 percent sea, 50 percent shore; III—80 percent shore, 20 percent sea.

mode of 50 percent sea and 50 percent shore with the factors given for both fisheries, a comparison can be made of the enforcement requirements calculated for the individual fisheries and for the two fisheries combined. At-sea enforcement requirements can be estimated from the factors given: For Fishery X, $VP=30$ and $FA=63{,}000$ square miles; for Fishery Y, $VP=1{,}200$ and $FA=56{,}000$ square miles; and for Fisheries X and Y, $VP=1{,}230$ and $FA=95{,}500$ (fishing areas for X and Y combined minus the common area, 23,500 square miles).

For Fishery X, using Equation (4), we find:

$$\frac{30 \times 0.50}{6} + \frac{63{,}000-[100 \times (30 \times 0.50)]}{1{,}200} = 53.8\ PDR.$$

For Fishery Y, we find:

$$\frac{1{,}200 \times 0.50}{6} + \frac{56{,}000-[100 \times (1{,}200 \times 0.50)]}{1{,}200} = 100.0\ PDR.$$

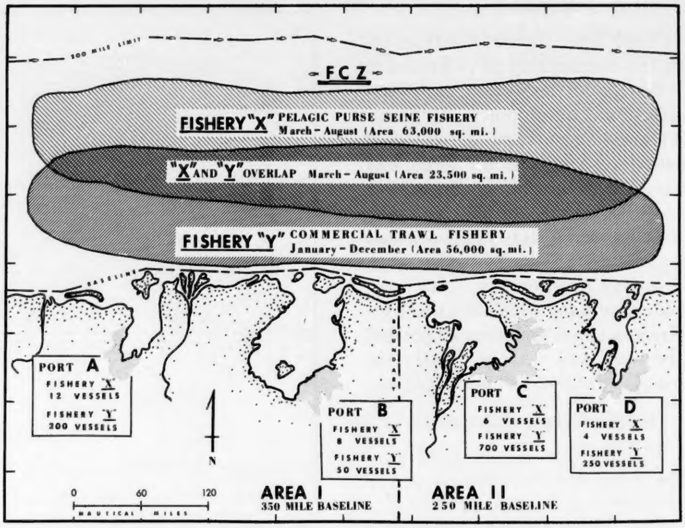

Figure 5.—Hypothetical purse seine and trawl fisheries scheduled for regulation.

For Fisheries X and Y, we find:

$$\frac{1{,}230 \times 0.50}{6} + \frac{95{,}500-[100 \times (1{,}230 \times 0.50)]}{1{,}200} = 130.8\ PDR.$$

In this example, the patrol vessel day requirements calculated for the combined fisheries are 23 less than the total calculated independently for the two fisheries to accomplish the same mission. The remainder of the enforcement estimate calculations for the two fisheries are given in Table 4. Note that a total of 5.1 staff years is indicated by separate calculations whereas 4.4 staff years are identified by joint calculations. Enforcement requirements for fisheries with common (or partly common) fishing areas and/or common coastlines should therefore be calculated jointly.

Table 4.—Summary of enforcement estimates for the hypothetical purse seine and trawl fisheries shown in Figure 5. Enforcement mode: 50 percent shore and 50 percent sea.

Sea Patrols

Fishery	Vessel pop.	Boardings required	Patrol days	Officers required
X	30	15	54	0.9
Y	1,200	600	100	1.7
X-Y	1,230	615	131	2.2

Shore Inspections

Fishery	Vessel pop.	Inspections required	Inspection days	Inspector required
X	30	15	12	0.1
Y	1,200	600	200	0.9
X-Y	1,230	615	205	0.9

Investigations

Fishery	Sea officers	Shore inspectors	Total sea/shore	Agents required
X	0.9	0.1	1.0	0.3
Y	1.7	0.9	2.6	0.8
X-Y	2.2	0.9	3.1	0.9

Support and total

Fishery	Field enf. required	Support required	Total staff years	
X	1.3	0.1	1.4	
Y	3.4	0.3	3.7	
			5.1	(Total X & Y)
X-Y	4.0	0.4	4.4	

Area Enforcement Estimates

Shore enforcement requirements for political or arbitrary divisions of coastline fronting a fishery or fisheries as shown in Figure 5 may be calculated independently. Areas I and II could represent two coastal states that have entered into agreements with the Federal government to enforce FCMA regulations within their boundaries under Fishery Management Plans (FMP's) for the hypothetical purse seine and trawl fisheries. Using Equation (8) for inspection days required with an enforcement mode of 50 percent shore and 50 percent sea and the factors given for each area, we can estimate the respective requirements for Fisheries X and Y for each area as follows: For Area I,

$$\frac{270 \times 0.50}{3} + \frac{350-[10 \times (270 \times 0.50)]}{60} = 45\,IDR.$$

and for Area II,

$$\frac{960 \times 0.50}{3} + \frac{250-[10 \times (960 \times 0.50)]}{60} = 160\,IDR.$$

Discussion

A standard quantitative method to estimate enforcement requirements for FMP's and other marine resource management or protection programs is essential to the equitable allocation of limited resources; both Federal and State. Without a basic system allocation, decisions are subjective. The system proposed here is for initial enforcement estimates in the Southeast Region of NMFS. If estimates for three enforcement modes covering primarily sea and shore enforcement and a combination of both are calculated, the mode ultimately selected will probably be covered. Experience with enforcement of regulations in individual fisheries should identify additional variables that can be inserted in formulas for revised estimates.

The methods for estimates proposed are based on one enforcement contact per season or year with each vessel in the fishery or combinations of fisheries. A management decision, however, can be made to increase or decrease the desired contacts per season or year and the equations will still apply by simply adjusting the vessel population for the desired contacts (e.g., double for two contacts a season or year or divide by two for contacts every two seasons or years) before adjusting the population for the enforcement mode. In initial estimates the proposed standard of one contact a year appears reasonable for fisheries of the southeastern United States and is therefore recommended until experience indicates otherwise.

The developers of regulations for management plans should consider the enforcement modes (sea, shore, or combinations) that will be required for compliance and the relative cost. Regulations that can be enforced at dockside are certainly cheaper to enforce than those that must be enforced at sea. If at-sea regulations are mandatory, the ratio of vessels in the fishery to the fishing area is an important consideration. For fisheries with few vessels and a large fishing area (such as the example used for the purse seine fishery), a 50 percent sea mode may require an effort equal to 100 percent sea enforcement to cover the fishing area. In such cases planners should attempt to write regulations that can be enforced entirely at sea and eliminate shore-side enforcement. The same applies when shore-side regulations are imperative. For fisheries with few vessels and an extensive coastline, a 50 percent shore-side enforcement mode may require the same effort as a 100 percent mode and at-sea regulations should be eliminated if possible.

Enforcement cost estimates can also be derived from the proposed equations by applying known dollar values to staff years of effort, vessel days, aircraft hours, and vehicle miles required for each fishery or combinations of fisheries. Further, the methods proposed can be used to prorate available enforcement dollars and personnel to meet minimum enforcement requirements for multiple fisheries. If "X" number of fisheries are to be regulated with "Y" enforcement resources, the staff years of effort required for individual fisheries can be converted to percentages of the total requirements for all fisheries and then applied to the available resources. Standardization of methods for making enforcement estimates is thus a prerequisite to developing a rational law enforcement resource allocation system.

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The Effect of Washing on the Quality Characteristics of Minced Fresh Croaker, *Micropogon undulatus*, Held in Frozen Storage

JAMSHYD G. RASEKH, MELVIN E. WATERS, and V. D. SIDWELL

Introduction

Croaker, *Micropogon undulatus*, makes up more than half of the industrial bottomfish landings from the Gulf of Mexico (Roithmayr, 1965), exceeding the present demand of this fish for human consumption. Small croaker, less than 0.5 pound, have not been used as a food fish, primarily because of the high preparation cost and the lack of convenient product forms for the consumer. Consequently, croaker are used primarily in pet food. To better utilize this resource for human consumption, new products must be developed and introduced to the market.

In recent years, mechanically deboned fish has been used in a variety of food products. The scarcity of frozen fillet blocks made from cod and haddock and the increasing demand for fish sticks and fish portions have resulted in production of minced fish by foreign countries for marketing in the United States (Miyauchi et al., 1975; Teeny and Miyauchi, 1972; and Whitaker, 1972).

In our laboratory, during 1975, we tested the quality of mechanically separated minced fish muscle made from several underutilized species, primarily croaker. We found that to produce an acceptable frozen minced product from croaker, it would be necessary to improve quality factors such as color and texture. This is exemplified in the Japanese process for making surimi (a semi-processed fish protein used in manufacturing kamoboko), i.e., washing of the minced flesh with chilled water before mixing with condiments and later freezing. The washing is to remove blood, soluble pigments, fat, and prooxidant materials, thereby improving color and stabilizing the functional properties during frozen storage.

The first phase of the earlier investigation (Rasekh et al., 1976) indicated that the color of minced croaker could be improved by washing the product with cold tap water for 2 minutes, using a 2:1 (w/w) ratio of water to fish. The loss of total solids from pre-frozen minced croaker after washing was 3.7 percent of the weight of the product. The purpose of this study was to determine the effect of washing minced fresh croaker on the chemical, microbiological, physical, and organoleptic properties of the product during long-term frozen storage.

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ABSTRACT—Minced fish was prepared from freshly caught croaker, Micropogon undulatus, *harvested from the western Gulf of Mexico. A portion of the minced flesh was washed for 2 minutes with tap water employing a ratio of 2:1 (w/w) of water to fish. Unwashed flesh served as the control. The washed flesh was drained until the final weight was approximately 3 percent more than the weight of the product before washing.*

Washed and unwashed flesh was prepared as minced blocks, placed in frozen storage, and evaluated periodically. Chemical, physical, microbial, and organoleptic analyses were conducted to determine the effect of washing on product quality during the 12 months of storage. Overall results indicated that the keeping quality of washed minced croaker blocks was superior to that of unwashed blocks. Improved flavor and odor scores of washed samples corresponded with lower TBA (thiobarbituric acid) values. Washing caused toughening of the texture in raw samples as measured objectively. The loss of total solids after washing was about 5.4 percent. There was no apparent difference in total aerobic plate counts between washed and unwashed fresh and frozen minced fish. Twelve months of frozen storage, however, reduced the TAPC (Total Aerobic Plate Count) 95 percent.

Experimental

Sample Preparation

Atlantic croaker were caught from coastal waters of the western Gulf of Mexico and processed into the minced form within a few hours after catch. The fish was first scaled, headed, gutted and thoroughly washed to remove the various organs, blood, debris, etc., from the gut cavity. The fish was then passed through a Bibun[1] separator (perforated drum with 5 mm diameter holes) to separate fish muscle from skin and bones.

Washing

Duplicate slurries consisting of 30 kg of tap water (18°C) and 14.5 kg of minced croaker (2:1 w/w ratio) were prepared. Each slurry was agitated in a 150-liter container for 2 minutes. After allowing the mixture to settle for 8 minutes, the water and soluble solids were decanted, and the flesh drained on cheesecloth placed over a screen. The average weight of the replicate samples after washing and draining was 15.0 kg (approximately a 3 percent increase). The washed samples were packed in 1-pound, wax-coated food cartons (7.5 × 21.5 × 3 cm) and frozen at −40°C in a plate freezer. A sample of unwashed minced fish was packaged and frozen in the same manner as the washed samples. After 24 hours, the cartons of washed and unwashed minced fish were removed from the plate freezer and

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

overwrapped with polyethylene. A portion of the unwashed sample was stored at −40°C and used as a standard reference sample for organoleptic evaluations. The remaining portions of the unwashed sample and the washed samples were stored at −18°C for further study. The unwashed sample, stored at −18°C, served as the control. Washed and unwashed samples were evaluated after 0, 3, 6, and 12 months of storage.

Loss of Total Solids

The drained water obtained from the washing of minced fish muscle was thoroughly mixed and a 20 ml sample taken and dried overnight in an aluminum dish at 98°C. The loss of total solids was calculated from the average of triplicate samples.

Chemical Analysis

Proximate analysis was performed according to the AOAC method (AOAC, 1970). Fat was measured according to the SAK method (Smith et al., 1964). Thiobarbituric acid (TBA) determination was performed as a measure of oxidative rancidity using Vyncke's method (Vyncke, 1972). Total volatile nitrogen (TVN) and trimethylamine-nitrogen (TMA-N) were determined as described by Cobb et al. (1973). Fatty acid profiles were obtained by gas chromatography on methylesters of the sample (Gauglitz and Lehman, 1963). Amino acids were determined with a Beckman automatic amino acid analyzer (Moore et al., 1958).

Functionality Measurement

The color of minced croaker was measured on both raw and cooked samples using a Hunter Color and Color Difference meter model 25 (Kramer and Twigg, 1966). A 120 g sample was placed in a clear plastic cup and the cup placed on a piece of glass over the color meter. The cup was covered with a black cover and the color values "L", "a", and "b" were measured. Only L values are reported. The color meter was standarized with a standard plate having the values of L = 92.8, a = −0.8, and b = −0.7.

The texture of the raw and cooked minced croaker was measured by the Kramer Shear Press (Kramer and Twigg, 1966) using a 3,000-pound pressure ring and a standard shear cell. For the raw material, 140 g of minced fish was placed in the standard cell and shear force values recorded. Cooking consisted of placing 170 g of sample in a glass container covered with aluminum foil and heating in an oven at 230°C for 30 minutes. After draining over a screen (Tyler, 425 μm) for 5 minutes, 140 g of cooked sample were subjected to the evaluation described above.

Cooking loss was determined by weighing the sample after cooking and draining it for 5 minutes. Results are reported as the percentage of liquid lost after cooking.

The amount of expressed water was determined by collecting and weighing the water released during the shearing process. Expressed water was calculated as the percentage of liquid released from the sample during shearing based on the weight of the sample before shearing. The pH of the minced sample was measured by placing the pH electrode directly into the flesh.

Sensory Evaluation

Frozen minced fish blocks were cut into 0.5-inch sticks, battered, breaded, and deep-fat fried in peanut oil for 2 minutes at 190°C. The sticks were cooled, wrapped in aluminum foil, and refrozen. The sticks were removed from frozen storage and heated in an oven at 204°C for 20 minutes. Samples were served to a taste panel consisting of 10 judges and quality assessed on appearance, flavor, and texture. Organoleptic quality factors were scored against the standard reference sample on a five-point scale, on which a three-point score was judged to be equal to standard reference sample, five points represented "like better" than standard and one point represented "like less" than standard sample.

Microbiological Examination

The total aerobic plate count (TAPC) was determined on washed and unwashed minced flesh before freezing (fresh samples) and after 0 and 12 months of frozen storage (frozen samples). The analyses were conducted according to the Manual of Products and Laboratory Procedure (BBL, 1973) for dairy products with the following modifications. Twenty-five g of fish were added to 225 ml of phosphate buffer, and the mixture was blended for 2 minutes. Appropriate serial dilutions were prepared and plated out on Standard Methods Agar. The fresh samples were incubated at 20°C for 72 hours and the frozen samples were incubated at 35°C and 20°C for 48 and 72 hours, respectively. Values are reported as an average of three analyses.

Results and Discussion

Loss of Total Solids

The percent loss of total solids, based on the weight of the minced fish before washing from two replicates, are shown in Table 1. After 2 minutes of washing, the average loss of solids was 5.37 percent. The value for each sample is the average of three determinations.

Chemical Analysis

In Table 2 we show the results of pH and proximate analyses of the unwashed and washed minced croaker from two replicate samples after 0 and 12 months of storage. Little differences

Table 1.—Loss of total solids from average of two replicate samples of washed minced croaker.

	Loss of total solids		
	Replications		
Sample	1 (Percent)	2 (Percent)	Average (Percent)
1	4.82	5.92	5.37
2	5.32	5.74	5.53
3	4.17	6.23	5.20
Average	4.78	5.96	5.37

Table 2.—Proximate analysis of unwashed and washed minced croaker from average of two replicates at 0 and 12 months of frozen storage.

		Proximate analysis					
Sample	Mo. of storage	pH	Protein	Moisture	Ash	Fat	NPN
			(%)	(%)	(%)	(%)	(%)
Unwashed	0	6.4	19.6	73.7	0.5	4.6	2.5
	12	6.3	19.5	75.0	0.5	5.0	1.4
Washed	0	6.5	17.0	77.0	0.9	4.4	1.9
	12	6.6	16.7	77.6	1.0	4.7	0.5

existed in values between the washed and unwashed samples for all factors evaluated, except NPN (nonprotein nitrogen). The small differences may be attributed to sample size and sensitivity of methods used rather than real difference. However, the slight increase in moisture content of the washed sample coincides with the observation made earlier during the washing procedure. The values for NPN's were lower for the washed sample at 0 months of storage and further decreased after 12 months.

The amino acid content of unwashed and washed minced croaker and the percent loss of amino acids (due to washing) at zero time storage are shown in Table 3. The percent amino acids of the washed sample was corrected for the approximately 3 percent increase in moisture. All amino acid values of the washed samples were lower than those of the unwashed samples except for glutamic acid and methionine, which were equal. The greatest loss was noticed for valine, glycine, and histidine and in that order. Overall, the total amino acids were about 1.1 percent lower for the washed samples as compared with the unwashed samples.

The fatty acid profile of unwashed and washed minced croaker at 0 and 12 months of storage is shown in Table 4. The results indicate that, initially (0 months storage), there was no apparent difference between the fatty acid profile of unwashed and washed samples. A comparison of the fatty acid profile of unwashed samples before and after storage showed that the saturated fatty acids, such as 14:0 and 16:0, 16:1 and 18:1, were somewhat lower after 12 months of storage. Also some polyunsaturated fatty acids, such as 18:1ω9, were lower after storage. Other polyunsaturated fatty acids, such as 18:2ω9, 22:4ω6, 22:5ω6, and 22:6ω3, increased appreciably after storage. The fatty acid profile of washed samples varied considerably betwen 0 and 12 months of storage. For example, fatty acid 16:0 decreased from 29.5 to 13.6 percent; fatty acid 22:4ω6 increased from 1.4 to 2.3 percent and 22:6ω3 increased from 2.3 to 5.1 percent. Variability was not confined to the polyunsaturated fatty acids.

The TBA values increased for both unwashed and washed samples during storage up to 6 months and there was little further change up to 12 months of storage. Washed samples showed lower TBA values during the entire storage period, indicating less oxidative rancidity development during storage (Fig. 1).

Figure 2 shows the production of total volatile nitrogen (TVN) for washed and unwashed raw minced croaker. Washed samples of raw minced croaker showed less TVN during storage than unwashed samples, indicating that materials responsible for the production of TVN were partly removed during the process of washing (Fig. 2).

TMA-N was determined on all samples during frozen storage. The amount of TMA was too small to be detected, indicating there was no significant bacterial spoilage.

Table 3.—Amino acid content of unwashed and washed minced croaker from two replicate samples at 0 months of storage.

Amino acids	Amino acid content: Unwashed	Amino acid content: Washed	Percent loss
	(%)	(%)	(%)
Lysine	1.95	1.86	4.6
Histidine	0.46	0.41	10.9
Ammonia	0.25	0.22	12.0
Arginine	1.20	1.18	1.7
Taurine	0.21	Trace	—
Aspartic acid	2.08	2.02	2.9
Threonine	0.93	0.92	1.1
Serine	0.81	0.80	1.2
Glutamic acid	3.27	3.17	0
Proline	0.77	0.74	3.9
Half cystine	Trace	—	—
Glycine	0.95	0.84	11.6
Alanine	1.21	1.16	4.1
Valine	1.26	0.96	23.8
Methionine	0.64	0.64	0
Isoleucine	0.90	0.87	3.33
Lucine	1.68	1.62	3.57
Tyrosine	0.73	0.72	1.4
Phenylalanine	0.80	0.76	5.0
Glucosamine	—	—	—
Total	20.1	18.99	

[1]Corrected for the approximate 3 percent increase in moisture.

Table 4.—Fatty acid profile of unwashed and washed minced croaker at 0 and 12 months of storage.

Fatty acids	0 mo. of storage: Unwashed	0 mo. of storage: Washed	12 mo. of storage: Unwashed	12 mo. of storage: Washed
	(%)	(%)	(%)	(%)
14:0	2.0	1.8	1.7	1.9
16:0	29.0	29.5	23.3	13.6
16:1	16.3	15.6	12.4	15.0
18:1	7.0	7.3	5.3	5.8
18:1ω9	20.3	20.8	15.7	17.9
18:2ω9	0.3	0.3	1.5	1.0
20:0	0.2	0.2	0.5	0.6
18:4ω3, 20:1, 18:4ω3	3.9	4.6	4.0	3.0
20:5ω3	4.4	4.3	7.4	5.9
22:4ω6	1.5	1.4	2.6	2.3
22:5ω6	0.3	0.2	1.6	1.3
22:5ω3	3.1	3.3	3.5	3.6
22:6ω3	2.5	2.3	6.0	5.1

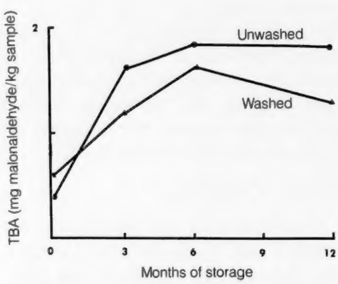

Figure 1.—Thiobarbituric acid (TBA) values of raw (unwashed and washed) minced croaker during 12 months of storage at −18°C.

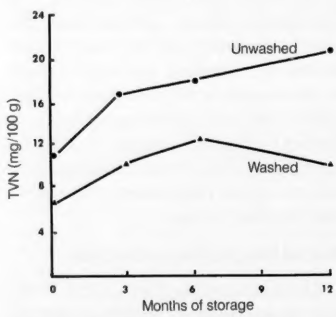

Figure 2.—Total volatile nitrogen (TVN) values of raw (unwashed and washed) minced croaker during 12 months of storage at −18°C.

Functionality Analysis

The objective determination of texture for raw and cooked samples before and after washing during frozen storage is shown in Figures 3 and 4. The shear force values of unwashed raw minced croaker increased as the months of storage increased. The values for the raw washed samples decreased after 3 months of storage and did not change appreciably after 6 and 12 months of storage. The washed sample had a much firmer texture than the unwashed

sample. For cooked croaker the shear values of washed samples decreased after 3 and 6 months of storage, then increased slightly after 12 months. The shear values of cooked unwashed samples decreased considerably after 3 months and decreased only slightly thereafter. The texture of unwashed cooked samples was much firmer than washed samples.

Although results of the objective color analyses are not shown, washed raw samples exhibited lighter color than unwashed raw samples, and there was little change in color of either sample during storage. Cooked samples (washed and unwashed) demonstrated much lighter color than raw samples. There was no appreciable difference in color between cooked washed and unwashed samples and the values did not change during storage.

The cooking loss for unwashed and washed samples is shown in Figure 5. The loss for washed samples was about 1.5 times greater than unwashed samples and both samples paralleled each other during storage.

The percent of expressed water of the raw washed sample increased slightly after 3 months of storage, further increased after 6 months, then decreased after 12 months to about the same level as that of initial storage. The raw unwashed sample decreased after 3 months of storage, increased after 6 months to about the level of initial storage, then decreased after 12 months to the same level as 3 months of storage (Fig. 6). The cooked washed sample exhibited slightly higher values than the unwashed sample and both samples paralleled each other after initial storage. The cooked washed sample decreased very slightly and the unwashed sample increased after 3 months of storage. Both samples decreased after 6 months, then increased after 12 months of storage.

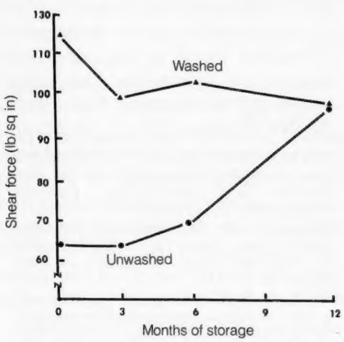

Figure 3.—Shear force values of raw (unwashed and washed) croaker during 12 months of storage at $-18°C$.

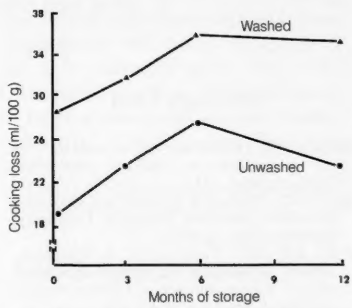

Figure 5.—The cooking loss of unwashed and washed minced croaker during 12 months of storage at $-18°C$.

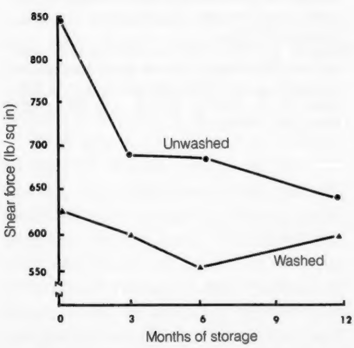

Figure 4.—Shear force values of cooked (unwashed and washed) minced croaker during 12 months of storage at $-18°C$.

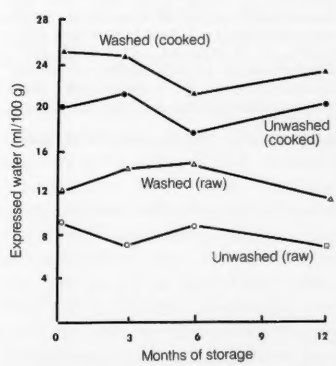

Figure 6.—The expressed water of raw and cooked (unwashed and washed) minced croaker during 12 months of storage at $-18°C$.

Organoleptic Analysis

The organoleptic evaluation of washed and unwashed samples for flavor, texture, and appearance is shown in Figure 7. The results indicate that washed samples maintained a better flavor than unwashed samples during storage. The texture of the washed sample was rated firmer than the unwashed sample at 0 and 6 months of storage. However, at 3 and 12 months the washed sample rated slightly lower than the unwashed sample which may not represent a real difference. Also, the appearance of washed samples received much higher scores than unwashed samples. This was due mainly to the improvement of color from washing, even though the fish sticks made from washed flesh shrunk considerably after cooking.

Microbiological Evaluation

The TAPC of fresh samples (before freezing) of washed and unwashed minced flesh was 4.3×10^5 and 2.4×10^5, respectively. Counts on the frozen samples were 1.9×10^5 for the washed sample and 2.7×10^5 for the unwashed sample after 0 months of storage. The values for both washed and unwashed samples were 1.2×10^4 after 12 months storage. There was no apparent difference in TAPC values between washed and unwashed fresh and frozen minced fish. Also, there was no difference between the fresh samples (washed and unwashed) and the frozen samples (washed and unwashed) stored for 0

months. However, there was approximately a 95 percent reduction in counts during frozen storage (12 months). There was no difference in counts between the two incubation temperatures of TAPC plates for the frozen samples. TAPC of all samples were in an acceptable range for commercial frozen minced fish blocks (Licciardello and Hill, 1978).

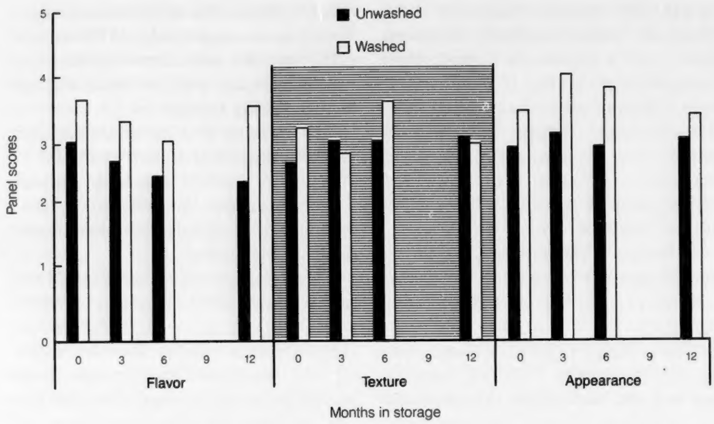

Figure 7.—The effect of washing on the flavor, texture, and appearance of fish sticks made from minced croaker.

Conclusions

The quality parameters of washed minced croaker blocks are better than those of unwashed minced blocks during 12 months of frozen storage. The slight loss of protein as a result of washing is minor compared to the beneficial effects offered by the procedure. Washing improved the flavor and appearance and, for the most part, texture as judged by a sensory panel. Washing the flesh also decreased the TBA values and TVN content during frozen storage. The color of raw and cooked minced flesh was improved by washing. Washing minced flesh did not lower the TAPC, and the values were within an acceptable range for commercial frozen minced fish blocks. Functional properties of minced croaker—texture, expressed water, and cooking loss—changed after washing due to a higher moisture content of the washed flesh and loss of some of the soluble protein responsible for water absorption properties during washing. Further work is needed to evaluate methods or additives that would prevent the loss of functional properties of the product due to washing. Additionally, economic and marketing studies are needed to demonstrate commercial feasibility of the washing process.

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U.S.-Japan Fishery Trade Talks Conclude on Cooperative Note

The United States Government and the Government of Japan agreed last summer to substantive changes in the Japanese Import Quota System for fishery products which will enable U.S. producers to gain increased access to the large Japanese market for seafoods.

The understanding was reached after a series of meetings in Washington, D.C., between representatives of the Government of the United States and the Government of Japan. Richard A. Frank, Administrator of the National Oceanic and Atmospheric Administration (NOAA) and head of the U.S. delegation stated: "The positive approach taken by the Japanese Government to our requests should encourage increased harvesting and processing by the U.S. industry of currently underutilized fish in our 200-mile Fishery Conservation Zone."

Japan will modify the criteria for imports under its quota system, thus expanding the opportunities for U.S. exporters to sell to Japanese firms. Changes in the allotment of quotas for species such as pollock will enable U.S. producers and Japanese buyers to conclude transactions which in the past have been foreclosed. Because of the absence of that market, the U.S. industry has been reluctant to devote efforts to these fisheries.

Frank noted, "Japan will expand the number of Japanese quota holders for herring imports for processing and will establish a new quota for herring to be used directly for food." He added that the Government of Japan will provide information on export opportunities in Japan, assist in resolving problems in specific fisheries trade transactions, and assist U.S. firms with technical cooperation in harvesting and processing.

The previous week, Secretary of Commerce Philip Klutznick met with Japanese Ambassador Okawara at which time the Secretary informed the Ambassador of the Administrator's determination to develop the U.S. fisheries industry and to increase fisheries exports.

The United States, in recognition of the Japanese offers, released 40,000 t of Alaskan pollock in the eastern Bering Sea which had been withheld from Japan in the 1980 fishery allocation in the U.S. 200-mile zone. The U.S. Government also stated it would release to Japan a substantial portion of other currently unallocated fisheries surpluses.

The U.S. delegation to these discussions included representatives of the Department of State and the United States Trade Representative. The Japanese delegation was headed by Director-General of the Japan Fisheries Agency, Nobuo Imamura.

Japan is the largest market for U.S. seafoods, importing over $560 million worth in 1979. Most of these purchases were in high-value species such as salmon and crab. The talks, which started earlier last spring in Tokyo, were designed to increase the amounts and to broaden the type of fish exported to Japan from the major U.S. resources within the 200-mile Fishery Conservation Zone, and by so doing to promote the development of U.S. harvesting and processing capacity in the currently underutilized species. Administrator Frank also announced that the Japan Deep Sea Trawlers Association was seeking arrangements with U.S. vessels to provide fish at sea off Alaska, as well as with seafood processors willing to sell processed fish to their Association.

NMFS Appointments Told

Four appointments to major positions in the National Marine Fisheries Service have been announced.

Robert W. McVey is the regional director, NMFS Alaska Region in Juneau; Alan W. Ford is the regional director, NMFS Southwest Region in Terminal Island, Calif.; William I. Aron is the Director, Northwest and Alaska Fisheries Center (NWAFC) in Seattle, Wash.; and Herbert A. Larkins is the regional director, NMFS Northwest Region in Seattle, Wash. The regional directors serve as the NOAA Assistant Administrator for Fisheries' regional representatives with recreational interests, State conservation agencies, the fishing industry and other constituencies, and the public within their areas. They are responsible for planning, organizing, and implementing fishery management and conservation programs, fishery development actions, habitat protection, and other services throughout the range of NMFS programs.

Robert W. McVey served as deputy regional director for the Alaska Region for the past 10 years prior to his new position. He began his career as a fisheries biologist in 1955 with the Missouri Conservation Commission. From 1957 to 1966, he served with the Bureau of Commercial Fisheries in Juneau as a fisheries biologist. In 1966, he began a 3-year tour as an assistant fisheries attache in Copenhagen, Denmark; served a short while in Washington upon his return from Denmark; and returned to Juneau in 1970.

Alan W. Ford served as a political advisor to the NATO Commander-in-Chief for the Mediterranean area until appointed to his new position. He has served in various positions of increasing responsibility in the State Department since joining them in 1956.

William I. Aron was serving as the director of NOAA's Office of Marine Mammals and Endangered Species when named to his new position. Aron has served as a research assistant professor for the University of Washing-

ton's Department of Oceanography, as head of the Biological Oceanography Group at the General Motors Defense Branch Laboratories, and as director of the Smithsonian Institution Oceanography and Limnology Program in Washington, D. C. From 1971 to 1978, he was director, Office of Ecology and Environmental Conservation for NOAA. In 1977, he was named as the U.S. Commissioner to the International Whaling Commission.

Herbert A. Larkins was serving as the director of the NWAFC's Resource Ecology and Fisheries Management Division when named to his new position. He began his fisheries career in 1961 as a research biologist doing high seas salmon and groundfish investigations with the Bureau of Commercial Fisheries Biological Laboratory in Seattle.

In 1971 Larkins went to Washington, D.C., as a fisheries advisor to the Commerce Department's Law of the Sea Task Force. In 1973 he returned to Seattle, becoming coordinator of international fishery research at the NMFS Northwest and Alaska Fisheries Center, Deputy Director, and then Director of the Division of Resource Ecology and Fisheries Management.

Larkins has served as a technical advisor to the U.S. delegation to bilaterial U.S./U.S.S.R. and U.S./Japan fisheries negotiations, technical advisor to and technical spokesman for the U.S. section of the International North Pacific Fisheries Commission, and fishery advisor to the U.S. Law of the Sea Delegation and delegate to the United Nations Seabed Committee.

Larkins received a B.S. degree in Fisheries and Wildlife in March 1956 from Michigan State University. He pursued a full-time graduate program in Fisheries Biology for a year and a half at the University of Washington.

In other actions, Robert T. B. Iversen has been named fishery attache to the U.S. Embassy in Tokyo. Iversen has more than 25 years of experience in fishery research and administration, beginning with the Bureau of Commercial Fisheries in 1955 as a fishery aide in Honolulu. He held positions of increasing responsibility until he was named to his previous post of deputy administrator of the National Marine Fisheries Service's Western Pacific Program office in 1971.

The United Nation's Food and Agriculture (FAO) has tapped NMFS consumer affairs specialist Clarence Cope for a second time to help a Latin American nation develop its fisheries resources. Cope departed for Brazil in mid-summer on a 2-year tour of duty as chief technical advisor and fish marketing economist to that government. In 1971, FAO arranged for Cope to take leave of absence to serve in the same capacity in Peru. Cope, who is working from offices in Brasilia, will advise a counterpart in the Brazilian government on developing marketing information systems, arrange training tours for Brazilians to study the fishery techniques of the United State's industry, organize workshops for Brazil's international and domestic fisheries marketing staff, and advise that country's food and fish technologists.

NINETEEN FISHERY MANAGEMENT COUNCIL MEMBERS APPOINTED

Eleven people have been appointed to vacancies on the nation's eight Regional Fishery Management Councils. Eight incumbents also have been reappointed, according to the National Oceanic and Atmospheric Administration (NOAA). Richard A. Frank, administrator of the Commerce Department agency, said all will serve 3-year terms.

The councils, established by the Fishery Conservation and Management Act of 1976, are responsible for preparing fishery management plans for stocks of fish found in their geographical areas. The act requires that council members be selected from lists of qualified individuals submitted by the governors of the states involved. New appointees are listed below.

New England Council: Bernard W. Corson, of Contoocook, N.H.; Joseph M. Brancaleone, executive secretary, Gloucester Fisheries Commission, Gloucester, Mass.; and Alan D. Guimond, president, Storington Seafood, Storington, Conn.

Mid-Atlantic Council: James F. McHugh, the SEPAC Group, Hampton, Va.; and Alfred J. Hurlock, Jr., president, Hurlock Roofing Company, Wilmington, Del.

South Atlantic Council: J. M. Pendarvis, Pendarvis Chevrolet, Edgefield, S.C.

Caribbean Council: Valdemar A. Hill, Jr., director of industrial relations, Virgin Islands Telephone Co., St. Thomas, U.S. Virgin Islands.

Pacific Council: Nicholas Curcione, associate professor, Department of Sociology, Loyola University, Los Angeles, Calif.

North Pacific Council: Joseph Demmert, Jr., commercial fisherman, Ketchikan, Alaska.

Western Pacific Council: Gertrude I. Nishirara, remedial reading and math tutor, Aiea, Hawaii; and Steven S. Amesburyl, assistant professor, Marine Laboratory, University of Guam, Agana, Guam.

Incumbents reappointed are, from the Mid-Atlantic Council: Harry M. Keene, DUO-EAST Industrial Equipment, Easton, Md.; and David H. Hart, marine fisheries consultant, Cape May, N.J.

South Atlantic Council: Margaret Stamey of Raleigh, N.C.

Gulf of Mexico Council: Billy J. Putman, Half Hitch Shop, Panama City, Fla.; John Green, president, Miller Vidor Land Co., Beaumont, Tex.; and George A. Brumfield, manager, Mississippi Operations, Zapata-Haynie Corporation, Moss Point, Miss.

Pacific Council: Herman J. McDevitt, attorney, Pocatello, Idaho.

North Pacific Council: Clem Tillion, commercial fisherman, Halibut Cove, Alaska.

In addition to the appointed members, the act allows the governor to appoint a state official with expertise in marine fishery management as a voting member of the council. The Regional Director of NOAA's National Marine Fisheries Service is also a voting member. Several non-voting members also contribute their expertise. These include the regional or area director for the U.S. Fish and Wildlife Service, the commander of the Coast Guard district, the executive director of the Marine Fisheries Commission, and a representative from the State Department.

Modest Whale Protection Gains Seen at IWC Meet

U.S. Whaling Commissioner Richard A. Frank has characterized the 32nd meeting of the International Whaling Commission in Brighton, England, last summer as having achieved "modest but important gains" for whale conservation.

Frank, administrator of the National Oceanic and Atmospheric Administration, expressed disappointment that the IWC had not adopted a moratorium on all commercial whaling, and pledged that the United States will continue to press for that goal, a hallmark of U.S. policy in the 24-nation body.

"Even without achieving an out-and-out worldwide whaling ban," Frank said, "we have taken steps in that direction, agreeing to additional restrictions on whaling of certain stocks that slice away at whaling operations bit by bit." The U.S. Whaling Commissioner predicted that within the next few years commercial whaling will come to an end worldwide.

"The decisions reached this year," Frank said, "follow a pattern that will make it uneconomical for the whaling nations to continue their operations. More and more, they will feel the pinch from limited whaling in a fuel-short world, and this will lead them to a continuing cutback on whaling activity."

Frank pointed to the following gains attained at the IWC meeting:

1) A significant reduction in the take of great whales. In the last 5 years, conservation-minded efforts in the IWC have produced a reduction from 34,000 to 14,500, the number permitted to be taken next year.

2) The Commission's agreement, of major importance, to a total ban on the taking of killer whales by factory ships, a decision assuring that tightened restrictions on hunting large whales will not leave whalers free to decimate this smaller species.

3) The reduction of the take of whales in the Southern Hemisphere from 20,000 in 1975 to something over 8,000 this year.

4) A decision that 1,419 whales may be taken this year in the North Pacific as opposed to 9,663 5 years ago.

5) An agreement by the Government of Spain, a whaling nation that joined the IWC last year, to cease all hunting of sperm whales.

6) An agreement to ban the use of the cold harpoon in the taking of large whales, assuring that the catch of these great creatures will be more humane by reducing the time between harpooning and death.

In addition, Frank hailed as a significant step IWC willingness to permit the U.S. to be responsible for a substantial portion of the regulation of the subsistence hunt of bowhead whales by Alaskan Eskimos. The IWC agreed this year to set a 3-year quota on the take of bowhead whales, 45 landed or 65 struck, whichever comes first. The highest take in any year would be limited to 17 whales landed.

"The 3-year regulation period provides for partial domestic management and gives the U.S. substantial flexibility in protecting the bowhead whale as an endangered species, while accommodating cultural and subsistence needs of the Eskimo," Frank said.

To carry out this decision, Frank said, the U.S. will start to allocate the quota over the 3-year period from 1981 to 1983, and to set other rules, such as whale sizes.

"During this time," he pledged, "I will work with the Eskimos and the scientific community to improve our knowledge of the bowhead and to make certain that our regulation is based on the best available information."

The bowhead is considered one of the most endangered species. The size of the herd is estimated at 2,300, compared with 15,000 to 20,000 in the 19th century, when commercial whaling began to destroy it.

The Eskimos of Alaska, some 5,000 in number, live in eight small villages on the north and west coasts. They have hunted the bowhead for 4,000 years, and have traditionally lived in harmony with these creatures. Today, they still hunt in 15-foot open boats made of animal skin and wood.

"The bowhead whale is an essential part of the Eskimo culture, and constitutes a spiritual and nutritional source which the IWC may not help to maintain," Frank said. "This new agreement points a way to manage an endangered species of whale, and also to conserve an endangered Eskimo culture."

Foreign Fishing Off West Coast Declines

The number of foreign fishing vessels off the Washington, Oregon, and California coasts has plummeted since passage of the Fishery Conservation and Management Act, reports the National Oceanic and Atmospheric Administration (NOAA). Information obtained by the Seattle regional office of NOAA's National Marine Fisheries Service, indicates there were only 11 foreign vessels in the area in mid-1980 compared with more than 100 vessels which fished annually off the coast prior to the establishment of the 200-mile fishery conservation zone.

The present fishery is directed toward Pacific whiting, *Merluccius productus*. Foreign fishermen are not allowed to keep any salmon caught incidentally with the Pacific whiting, the Commerce Department agency said. Five of the foreign vessels were Soviet joint-venture processing vessels receiving whiting from U.S. trawlers.

Consistent with President Carter's policy to deny the Soviet Union fishing privileges in U.S. waters, the Soviet vessels are not allowed to fish as they did last season, but may only receive the catches delivered to them by the U.S. vessels under the agreement. The Soviet Union received no direct whiting allocation in 1980.

In addition to the five joint-venture processing vessels, there were six Polish vessels in the area. This number could increase as the season progressed, but the total number of foreign vessels off the West Coast at any one time was not expected to exceed last year's high.

The 175,000 metric tons optimum yield (total allowable catch) of Pacific whiting in 1980 has been distributed as follows: 40,000 metric tons (t) were reserved for the domestic fishery, of which 12,000 t may be processed by shore-based processors and 28,000 t by the foreign processing vessels under the joint venture arrangement. Of the remaining 135,000 t, 35,000 t have been put in a reserve to be released later for

foreign fishing if not needed by U.S. fishermen. Of the 100,000 t available to the foreign fishery, approximately 40,000 t were allocated to Poland and 30,000 t to Mexico. Ninety percent of the Mexican allocation is held in reserve, however, pending clarification of Mexico's intent to enter the fishery and use the allocation.

The remaining 30,000 t were "still in the bank," NMFS officials reported, and it was not clear at mid-year how much of it would be allocated during the season.

Foreign Fishing Vessels Settle for $1.8 Million

Three foreign fishing vessels seized last year for violating regulations permitting them to fish within the U.S. 200-mile fishery conservation zone have agreed to pay more than $1.1 million in settlement of these violations, the National Oceanic and Atmospheric Administration (NOAA) has announced.

The *Tsuda Maru*, a Japanese stern trawler, was seized in the Bering Sea in January 1979 after special agents of NOAA's National Marine Fisheries Service discovered more than 54 tons of fish that had not been recorded in compliance with the fishing regulations. A settlement of $700,000 was paid in lieu of the government pursuing its complaint for forfeiture of the vessel.

Two Korean stern trawlers, *Seo Yang* and the *Pung Yang Ho*, were seized off Alaska for discrepancies in their fishing logs. The two cases were settled for a total amount of $400,000.

Altogether, eight of 14 foreign vessels seized last year have paid more than $1.8 million in settlements, with five cases yet to be decided. One ship taken into custody was released as a result of the U.S. Attorney's decision not to prosecute. Any further action will be handled through the administrative penalty procedure. By mid-year, six ships had been seized during 1980, but no final decision had been reached regarding penalties.

The number of foreign fishing vessels seized for violations within the 200-mile fishery conservation zone has increased yearly since the zone was created in 1977. That year, three vessels taken into custody paid a total of $589,000 in settlement of the cases. In 1978, 11 vessels paid $680,000 in FCMA violation actions.

Skipjack Tuna Spawn in Captivity

Skipjack tuna, *Katsuwonus pelamis*, called aku in Hawaii, spawned in captivity last summer for the first time anywhere in the world. The event took place in the experimental tanks at the Kewalo Research Facility of the NMFS Southwest Fisheries Center's Honolulu Laboratory, according to Richard S. Shomura, Director of the Laboratory. The Kewalo Research Facility has been gearing up for last summer's experiments to artificially induce tunas to spawn in captivity, Shomura said.

The skipjack tuna, 13 in all, were delivered to the Kewalo Research Facility at about 11 p.m. on 28 June by Albert Grace, skipper of the FV *Bluefin*, said fishery biologist Thomas K. Kazama who has overall supervision of the project. The following morning, about 6 a.m., evidence of spawning was observed by the scientists monitoring the fish. They found approximately 110,000 "ripe" eggs in the water strainer from the tank the tuna were swimming in.

Following this discovery of the spawning, a sexually ripe male and female were taken from the holding tank and stripped of their eggs and sperm. The eggs were artificially fertilized by mixing them with the sperm and the thousands of fertilized eggs were placed in special aquaria for careful observation. The tiny skipjack tuna larvae hatched after 30 hours and Kazama and his team began attempts to rear the larvae by feeding them with marine plankton from cultures established for this purpose.

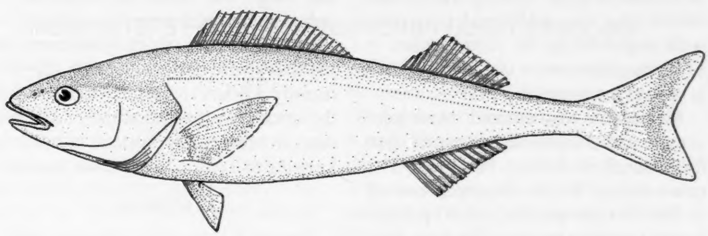
According to Calvin M. Kaya, a visiting scientist from the faculty of Montana State University, Bozeman, Mont., who is participating in the experiments, this successful spawning is another breakthrough in attempts to routinely induce captive tunas to spawn in shoreside tanks. Last summer another species of tuna, the kawakawa, *Euthynnus affinis*, was induced to spawn in captivity through hormone treatments at the Kewalo Research Facility. The only other instance of a tuna spawning in captivity is that of bluefin tuna, *Thunnus thynnus*, spawning in large netted enclosures in Japan.

These two "firsts" of artificially inducing captive tunas to spawn constitute a significant development in tuna research, said Shomura. Scientists at the Honolulu Laboratory hope that these initial successes will lead to the development of techniques to routinely induce tunas to spawn and to rear their young in captivity. Shomura added that such research is made possible by the cooperation of fishermen of the likes of Captain Grace who have been bringing back live fish for these experiments.

Tuna Energetics Study

Andrew R. Dizon, fishery biologist and leader of the Experimental Ecology of Tunas program at the Southwest Fisheries Center's Honolulu Laboratory has had a proposal on tuna energetics approved by the National Science Foundation for 2 years of funding. The study submitted jointly to NSF by the Southwest Fisheries Center, the California Institute of Technology, University of Wisconsin, and the University of Michigan, is titled, "Tuna energetics and hydrodynamics: An interdisciplinary study of energy transfers." The research will be conducted at the NMFS Honolulu Laboratory which supports the only facility in the world devoted to the maintenance and culture of tunas for experimental studies under controlled conditions.

Mexico Initiates New Sablefish Fishery



Sablefish, *Anoplopoma fimbria*.

Sablefish, or black cod, *Anoplopoma fimbria*, has been discovered in commercial quantities off the coast of Baja California along Mexico's Pacific coast. The range of the species was previously known to extend from Alaska as far south as the Baja Peninsula, but it was not until 1977 that sablefish was found off the Baja coast in commercial quantities. Mexico has now initiated a new fishery for that species with the assistance of Korean and Japanese fishermen.

The Species

Sablefish is easily recognizable. It is distinguishable by its streamlined form, two dorsal fins, five teeth in patches, and more than 15 spines in each dorsal fin. The fish has black skin, white flesh, almost no bones, and only a few scales.

The behavioral pattern of sablefish is still not well understood. Fishermen, for example, report that traps on the same line, set very close to each other, frequently yield sharply different catch. Biologists cannot explain why some traps are brought up full of sablefish, while others remain empty. Biologists do know that the younger the fish, the nearer they stay to the surface. Larvae and eggs are often found in bays and inlets near the surface, 1-2-year olds dwell in depths to 150 m and adults are found from 150 to 1,200 m deep. Mature fish, however, are most commonly found in depths ranging from 400 to 800 m. Fishermen thus generally set their traps 400 to 800 m deep to obtain optimum catch.

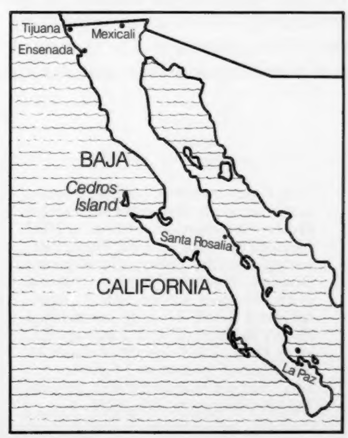
Adult sablefish are about 55 cm long and weigh 2 kg. Juveniles and adults tend to school separately. The adults are also found in mixed schools with other species. Sablefish predators include halibut, other large predatory fish, and sea lions. Sablefish eat primarily walleye pollock, Pacific herring, grenadiers, and other small fish, as well as shrimp and squid.

In the western Pacific, sablefish range from the Gulf of Alaska south to Baja Peninusla. It was previously believed that stocks off the Baja were not adequate to support a commercial fishery. Even somewhat to the north, off southern California, the sablefish catch was only incidental to directed fisheries for other species. Full information on sablefish stocks off the Baja coast is still not available. Commercial fishing has so far been concentrated north of Cedros Island.

Migratory patterns of black cod are also not fully understood. Tagging studies by the United States, Japan, and the Republic of Korea (ROK) biologists, show that sablefish are essentially sedentary. More than 50 percent of the fish tagged during 1971-1975 were recovered near the area in which they were tagged.

Joint Ventures

The Mexican Government has promoted joint ventures with the ROK to initiate a fishery for sablefish. In 1978, the Mexican Propesca Corporation and the Korean Marine Industry Development Corporation (KMIDC) agreed on



a joint venture to deploy two vessels to fish for black cod within Mexico's 200-mile Exclusive Economic Zone. The agreement provided for 51 percent Mexican ownership and 49 percent ROK ownership. It also provided that the Korean officers and crew be gradually replaced by Mexicans upon completion of training with the ultimate end being Mexican officers and crew.

The catch must be landed and processed in Mexico. The two vessels caught 2,100 metric tons (t) worth about $2 million in 1978. Fishing was so successful that two additional longliners were deployed by the joint venture in 1979, but information on the 1979 catch is not yet available.

Mexico has also entered into a joint venture with a Japanese company to fish for sablefish off the Baja Peninsula. The new company will be 60 percent owned by the Mexican partner and 40 percent by the Japanese partner. The joint venture is constructing 5 vessels in Japan at a cost of US$0.8 million each.

Fishing Methods

The Mexican joint ventures apparently employ the same gear and methods as do the ROK and Japanese fishermen in the North Pacific. Each vessel carries three longlines of which two are deployed and one held in reserve. Each longline set consists of 500 concave wire baskets closely placed from 360 m to 1,250 m deep. These traps are cone-shaped and are about 60 cm high with a lower diameter of approximately 140 cm and an upper diameter of 85 centimeters. The framework is of reinforced wire rods, with 4-8 cm mesh nylon webbing. A funnel on one side starts at full trap height, tapers to about a 10-inch opening, and extends one-half to three-fourths of the way into the trap. The floor of the trap is opened and closed by a pucker similar to that used on a purse seine.

Bait, primarily squids and anchovies, is placed in a 1-gallon plastic container. The container is perforated so that the fish can smell the bait without eating it once they enter the trap. The traps are attached to lines up to 15 km long. The lines are attached to radar-monitored buoys to assist recovery. A heavy duty winch is necessary to lift heavy wire baskets. It takes approximately 3 hours to set the longlines and the catch is recovered at the end of the day. A brine spray system is used to keep the fish chilled aboard the vessels.

Processing

The catch is landed in Mexican ports. At the dock, the fish is cleaned with wire brushes and deheaded. As soon as the fish have been cleaned, they are salted and graded by size, then frozen at −50°C. After 12-14 hours the frozen fish are transported to cold stores, where the temperature is maintained at −30°C. Sablefish is an excellent species for smoking because its flesh is oily. Mexican-caught sablefish is mostly exported for smoking. The joint venture company is experimenting with processing sablefish in Mexico. The fish is sliced into thin fillets which are sprayed with soy sauce and frozen. Most of this product will be exported to Japan.

Developing a Market

The Mexican Government has attempted to develop a domestic market for sablefish. The Government attempted to sell the fish at greatly reduced prices ($0.90/kg) hoping to lure potential customers. Results to date, however, have not been encouraging. Particularly popular species command high prices on Mexican markets, but so far Mexican consumers have shown no special preference for sablefish, even though it has white flesh and few scales and bones.

The joint venture is now studying the possibility of pickling the fish to make a product called "ceviche" which is popular in Mexico and would attract more Mexican consumers. The original agreement with the Koreans specified that at least 20 percent of the catch was to be marketed domestically. That percentage was to increase as the domestic demand grew. Lack of domestic demand has not allowed for an increased domestic quota. It is likely, therefore, that the primary market for sablefish will continue to be foreign countries, primarily Japan where this species is highly prized.

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Daily (LSD) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Sweden Gets More Baltic Sea Cod

Swedish fishermen are catching more cod in the Baltic Sea than ever before. A single fishing trip is reportedly often sufficient for catching the agreed upon amount of cod, 3,000 kg per person per week. This is a new development for the Swedish fishing industry which has been having problems for decades and has been suffering from the steady decline in the number of fishermen.

Today fishermen are earning good money and there is once again incentive for young people to enter the industry. The main problem which is now facing the Swedish fishing industry is the inability of the processing plants to handle the increased volume of fish. Although the Swedish fishing quota for cod is 30,000 t annually, because of the inadequate size of the fishing fleet, fishermen won't be able to even approach this number.

The Swedish demand for cod is far exceeding the domestic supply. Only one-third of the cod consumed in Sweden is caught domestically. Thus although the Swedish fisherman earns less than 3 skr for one kilo of cod, the consumer must pay between 15 and 20 skr (US$1 =4.171 skr). (Source: LSD 80-14.)

Russia Tries Titanium in Fish Processing Machines

Soviet engineers have reportedly met with success in substituting titanium for rust-free steel in the construction of fish processing machines. The corrosion of metal caused by seawater reduces the life of machines made from steel and causes breakdowns and delays in their operation. The final product is also sometimes affected by the corrosion.

The Soviet Union's large factory ship fleet has suffered greatly from such corrosion and the use of titanium is viewed as a solution to this problem. Corrosion sensitivity of a metal can be determined by measuring the depth of the metal which undergoes change. It was found that after more than 480 days of submersion in standing water, the rust-free steel was affected up to a depth of 0.24 m, while titanium did not show any signs of corrosion whatsoever. These same results were obtained in tests of an even longer duration. The data needed to carry out a comparison between the initial cost of the titanium and the cost of repairs and maintenance which would be born by machines built from titanium have not yet been compiled, however. (Source: LSD 80-14.)

Canada Signs Fisheries Pact With Faroe Islands

An agreement on fisheries relations between Canada and the Kingdom of Denmark has been signed. The agreement was signed on behalf of Canada by Roméo LeBlanc, Minister of Fisheries and Oceans, and on behalf of the Kingdom of Denmark and the Faroe Islands by Danish Ambassador Vagen Korsbaek and Lagmand Atli Dam, Head of the Home Government of the Faroe Islands.

The agreement follows the standard form of previous agreements. It provides recognition of the Canadian 200-mile fishing zone, access to allocations of fish surplus to Canadian requirements, protection for Canadian salmon, undertakings regarding commercial cooperation concerning fish products and also recognizes the special interest of Canada in the stocks beyond and immediately adjacent to the 200-mile limit off the Atlantic coast.

The Agreement is one of a series concluded with countries which have traditionally fished off the coasts of Canada. The Faroe Islands is a self-governing region of the Danish Kingdom which has traditionally sent fishing vessels to waters which now fall under Canadian jurisdication.

On signing the Agreement, LeBlanc referred to these traditional fisheries. "Faroese fishermen can be assured of a share in what is surplus to Canadian needs in our waters," he said, adding, "The Faroese have cooperated with us to establish conservation measures through NAFO, and our bilateral agreement provides a sound basis for continuing cooperation in the conservation of fish stocks in the northwest Atlantic Ocean."

Japan's 1979 Fisheries Production Down 2 Percent

Japan's annual landings of fisheries and fish culture products for 1979 totalled 10,632,000 metric tons (t) down 2 percent from the 1978 figure, according to the data released by the Ministry of Agriculture, Forestry, and Fishery. The landings by types of fishery are shown in Table 1.

The marine fisheries catch, representing some 90 percent of the total, amounted to 9.5 million t, a decline of about 10 percent from 1978. In previous years, the decreasing distant-water fisheries catch has been more than offset by increased landings from Japanese offshore fisheries. In 1979, however, this was not the case. Offshore landings decreased even more than distant-water landings, and a slight increase in the coastal catch did not compensate for the losses.

The decreasing distant-water catch reflects the continued effect of the establishment of 200-mile fishery zones by many countries where catch quotas for Japanese fishermen have been imposed. However, the rate of decline in the distant-water catch, which was as high as 20 percent in 1978, has decreased to only 3.6 percent in 1979. Significantly, the proportion of the distant-water catch taken in the U.S. fishery conservation zone decreased only marginally from 55.5 percent in 1978 to 53.9 percent in 1979, or by only 1.6 percent. It was the decline of 211,000 t in the 1979 Japanese offshore catch that contributed most to the overall decline in its marine fisheries catch.

Japan's inland fisheries catch, on the other hand, increased slightly (by 1 percent) over 1978 figures. A significant decline occurred in Japan's harvest of whales, which was 17 percent below that in 1978. (Source: NMFS Foreign Fisheries Analysis Division.)

Table 1.—Japan's fishery production by major fisheries for 1976-79 in 1,000 metric tons.

Fishery	Year 1976	1977	1978	1979	Percentage of change, 1978 to 1979
Marine					
Distant-water	2,949	2,657	2,132	2,056	−3.6
Offshore	4,656	4,924	5,559	5,348	−3.7
Coastal	2,000	2,107	1,990	2,116	+6.3
Aquaculture	850	861	917	880	−4.0
Total	10,445	10,549	10,599	9,521	−9.8
Inland					
Aquaculture	77	82	90	94	+4.4
Other	124	126	138	136	−1.4
Total	201	208	228	231	−1.3
Grand Total	10,656	10,757	10,827	10,632	−1.8
Whales	9,632	9,299	5,924	4,918	−16.9

Source: U.S. Regional Fisheries Attache American Embassy, Tokyo.

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents (address given at end of title paragraph on affected publications) or from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Writing to the agency prior to ordering is advisable to determine availability and price, where appropriate (prices may change and prepayment is required).

NOAA Technical Report NMFS SSRF-730. Temple, Robert F., and John A. Martin. **"Surface circulation in the northwestern Gulf of Mexico as deduced from drift bottles."** May 1979. 13 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Abstract

Drift bottles were released monthly at predetermined stations in the northwestern Gulf of Mexico from February 1962 to December 1963. Of the total 7,863 bottles released, 12 percent (953) were recovered within 30 days after release. Analysis of the monthly recoveries revealed seasonal shifts in the flow of surface waters. Between September and February the dominant flow was west along the Louisiana and east Texas coasts, shifting southwest along the southern Texas coast. Between March and May, currents underwent a transitional period, shifting to the north and onshore, particularly along the south and central Texas coast. Converging currents, also apparent along the south Texas coast, appeared to progress up the coast with time. In June and July the surface flow was to the northeast and east. August was another transitional period with currents appearing to weaken and turning onshore. Movements of surface waters appeared directly related to prevailing winds.

NOAA Technical Report NMFS SSRF-735. Dahlberg, Michael L. **"History of the fishery and summary statistics of the sockeye salmon, *Oncorhynchus nerka*, runs to the Chignik Lakes, Alaska, 1888-1966."** August 1979, 16 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C 20402

Abstract

Annual runs of sockeye salmon to the Chignik Lakes, Alaska, decreased from an average of 1.9 million during the period 1922-39 to an average of 0.9 million from 1949 to 1966. To study the dynamics of the runs' historic catch, escapement and age

The Fisheries of Australia

Australia, with its 20,000 km coastline, possesses considerable fisheries resources which are reviewed in **"Fisheries of Australia"** by Peter Pownall and published by Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey, England. The author, long-time editor of *Australian Fisheries*, has produced probably the most comprehensive survey of Australia's fisheries, from Captain Cook's 1770 voyage of discovery, to the 20th century.

Though not a detailed technical text, the book does delve deeply into both past and present developments in Australia's fisheries. Chapters treat rock lobsters, prawns, demersal fish, pelagic fish, reef fish, scallops, abalone, pearls, whales, freshwater fish, and aquaculture. Others examine fishing vessels and gear, fishing methods, fish marketing, research, fishery administration and management, sport fishing, and fishing in neighboring nations. The book is indexed and a list of volumes for further reading is included. All in all, it's a good close look at Australia's fisheries. The volume is available from the publisher for £7.24

Tunas and Billfishes

Publication of **"Tuna and Billfish, Fish Without a Country"** by J. Joseph, W. Klawe, and P. Murphy has been announced by the Inter-American Tropical Tuna Commission, P.O. Box 1529, La Jolla, CA 92093. Authors Joseph and Klawe are, respectively, Director of Investigations and Senior Scientist, IATTC; Murphy is a science writer in La Jolla, Calif.

The volume is both well written, accurate, and handsomely designed and printed. It features eight full-color paintings of tunas and billfishes by George Mattson, also of La Jolla, plus about 70 other illustrations. The Foreward is by Roger Revelle.

In brief, the book discusses tuna and billfish biology and migrations, world harvest, conservation, and management. Specific data is presented, with line art, on the names and geographic distribution of tunas and related species; all-tackle world records (from the International Game Fish Association) are listed, as is a bibliography for in-depth reading. The volume is available from the IATTC at the above address for $7.95 postage paid.

Early Life of Fish Discussed

Publication of **"Early Life History of Marine Fish: The Egg Stage"**, by Gotthilf Hempel, has been announced by the University of Washington Press, Seattle. It is a product of the author's lectures at the University of Washington in the spring of 1975 and describes briefly the early life history of fish and outlines objectives for future studies.

The author covers the development of egg cells and details variations in fecundity and egg size in marine fish. The incubation period of demersal and

structure data were compiled by spawning stock and brood year. The history of fishing and management of the runs from inception of the fishery until 1966 is described. The high seas and coastal distributions of Chignik sockeye salmon indicated significant interception by the fishery in only one area other than the Chignik Bay and Chignik Lagoon; the fishery at Cape Igvak started in the mid-1960's. Results of the study were used to construct parent-progeny relationships that formed the basis for a management strategy to restore the runs to their former level of abundance.

NOAA Technical Report NMFS SSRF-736. Wahle, Roy J., and Robert Z. Smith. **"A historical and descriptive account of Pacific coast anadromous salmonid rearing facilities and a summary of their releases by region, 1960-76."** September 1979. 40 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Abstract

A brief history of the artificial culture of salmonid fishes in North America is presented. The report contains a Pacific coast section followed by sections for each of six major regions on the coast: Alaska, British Columbia, Washington coastal and Puget Sound, Columbia Basin, Oregon coastal, and California. The Columbia Basin is further divided into three subregions. The Pacific coast section provides information on current production of anadromous salmon (*Oncorhynchus* spp.) and trout (*Salmo* spp.). Each regional or subregional section contains a short history and background, a map with current rearing facilities located, a general hatchery information table, and migrant release tables summarized by species. In the final portion of the report, changes in numbers of facilities, species reared, rearing techniques, and size at time of release are discussed.

NOAA Technical Report NMFS SSRF-737. Perrin, W. F., W. E. Evans, and D. B. Holts. **"Movements of pelagic dolphins (*Stenella* spp.) in the eastern tropical Pacific as indicated by results of tagging, with summary of tagging operations, 1969-76."** September 1979. 14 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Abstract

Through 1976, 3,712 small cetaceans were tagged in the course of research cruises operating out of the NMFS Southwest Fisheries Center. These included 2,996 spotted dolphins, *Stenella attenuata*; 324 spinner dolphins, *S. longirostis*; 193 common dolphins, *Delphinus delphis*; and 113 bottlenose dolphins, *Tursiops truncatus*. Others tagged in small numbers included Pacific white-sided dolphins, *Lagenorhynchus obliquidens*; striped dolphins, *Stenella coeruleoalba*; and a short-finned pilot whale, *Globicephala macrorhynchus*. Several types of tags were used. Tags have been recovered from 97 spotted dolphins and 7 spinner dolphins. Time at liberty ranged from less than 2 hours to more than 4 years. Net distance traveled ranged from 7 to 582 n.mi. Average short-term movement in the spotted dolphin is 30-50 n.mi./day; range is 200-300 n.mi. in diameter, and seasonal onshore-offshore migrations may exist.

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pelagic eggs is considered mainly in relation to ecological aspects.

The paperbound 70-page volume is available from the University of Washington Press, Seattle, WA 98195 for $7.50.

Japan's Fish Import Rules

The Southwest Region, National Marine Fisheries Service, has compiled a report entitled "A Survey of Japan's Import Regulations on Fish and Shellfish Products." This 78-page report provides information on import inspection procedures, government regulations on food sanitation and additives, government requirements for labeling, and industry quality standards by species.

A free copy of the report, in limited quantities, can be obtained upon request in writing to the author: Sunee C. Sonu, Southwest Region, National Marine Fisheries Service, NOAA, 300 South Ferry Street, Terminal Island, CA 90731.

The Atlantic Salmon Symposium Proceedings

"Atlantic Salmon: Its Future," edited by A E J Went and published by Fishing News Books Ltd, 1 Long Garden Walk, Farnham, Surrey, England, presents the papers and discussions of the second International Atlantic Salmon Symposium held in Edinburgh, Scotland, September 1978, under the sponsorship of the International Atlantic Salmon Foundation and the Atlantic Salmon Research Trust.

The objective of the symposium was to discuss the apparent bleak prospects for the species and to consider the role which the species could and should play in the future. The volume provides a wealth of data, beginning with a general review of the state of the Atlantic salmon fisheries of the north Atlantic, with papers stressing the many international aspects involved and the complications of the present legal systems.

A notable part of the book gives individual review of the ecological factors affecting stocks and their management in Scotland, England, Wales, Eire, Canada, France, and New England. Practical methods of improving the situation are dealt with in papers on ocean ranching, genetic variation in production traits between strains, management in floating sea pens, and the role of genetics in management.

The volume winds up with an extensive look at the future and stresses the need for new harvesting policies. Chapters also discuss Atlantic salmon harvests by commercial and sport fishermen—and poachers. The 272-page book is available from the publisher for £10.50 and is a valuable addition to the Atlantic salmon literature.

A Special Atlantic Halocyprid Ostracod Issue

Volume 8, Numbers 1-2 (1979) of *Progress in Oceanography* has been devoted to a lengthy report entitled "Studies on Atlantic halocyprid ostracods: Their vertical distributions and community structure in the central gyre

region along latitude 30°N from off Africa to Bermuda" by Martin V. Angel, a coeditor of the journal.

In comparing the vertical ranges and abundances in the surface 2,000 m of the water column, the author shows how the planktonic ostracods change clinally between two widely different North Atlantic positions. The order of species abundances were very different at the two localities and analysis of size spectra showed the trend towards more larger organisms with increasing depth was reversed below 800 m.

Most data covers the detailed information on the species sampled (over 60), and the interpretation of the data gives insights into the community structure, the size frequency distributions, the reproductive strategies of the species, and the patterns and possible reasons for their vertical migrations.

The 124-page softbound issue is available for $27.50 from Pergamon Press, Fairview Park, Elmsford, NY 10523.

A Review of Fish Behavior

"Diversity and Adaptation in Fish Behavior", by Miles H. A. Keenleyside, published by Springer-Verlag, New York, outlines fish behavior and its influence on their adaptation to a variety of marine and freshwater habitats. Chapters examine locomotion, feeding behavior, anti-predator behavior, selection and preparation of a spawning site, breeding behavior, parental behavior, and social organization of fishes. Numerous references are cited and the volume has a subject and systematic index.

Though not an exhaustive review, the volume does provide a sampling of pertinent and relatively recent (1978) literature. Examples have been selected to illustrate the range and variety of behavioral adaptations that enable fishes to cope with the problems of food, predation, and reproduction. The 208-page hardbound volume, eleventh in the series "Zoophysiology and Ecology," costs $37.90 and is available from the publisher at 44 Hartz Way, Secaucus, NJ 07094.

Bering Sea Shellfish and Fish Resources Charted

In May through August 1979, an extensive, demersal crab-groundfish resource survey was conducted in the eastern Bering Sea by the Northwest and Alaska Fisheries Center. The results of this survey are available as data sheets representing the catch in pounds per hour trawled. These sheets are scaled to overlay National Ocean Survey Chart No. 16006.

The data sheets provide a comprehensive picture of the distribution and relative abundance of each resource within the area 54-61° N latitude, 156-176° W longitude. Data is available on the following fish: Total groundfish, walleye pollock, Pacific cod, yellowfin sole, Pacific halibut, total flounder, and total rockfish. Shellfish charts include: Red king crab, blue king crab, Tanner crab (*C. bairdi*), Tanner crab (*C. opilio*), Korean horsehair crab, and total snails. Miscellaneous charts are for total cephalopods and pollock average lengths.

Send orders to the Bering Sea Project, Resource Assessment Division, Northwest and Alaska Fisheries Center, 2725 Montlake Boulevard East, Seattle, WA 98112.

Marine Invertebrates

"Marine Life", subtitled "an illustrated encyclopedia of invertebrates in the sea" has been published by John Wiley & Sons, Inc., One Wiley Drive, Somerset, NJ 08873. Containing 1,300 photographs in full color, the volume presents a comprehensive discussion of 27 phyla with marine representatives.

Author David George is a Principal Scientific Officer in the Zoology Department of the British Museum (Natural History) where he specializes in marine worms. Coauthor Jennifer George is a Principal Lecturer in Life Sciences at the Polytechnic of central London.

An account of general morphology and ecological relationships precedes a classification into classes, orders, and families, incorporating recent views on taxonomy of the groups. The majority of the commonly occurring families are illustrated by representative species, in color where possible, alive and in their natural environment. Photo captions include biological, behavioral and ecological notes.

The volume is intended both for students and for amateur and professional biologists. Covering such a wide area forced the authors to omit discussion of nonparasitic forms and to give little more than passing reference to larval stages. The large format volume contains 288 pages and is available from the publisher for $39.95 plus $1.25 postage.

World Game Fish Records Published

Publication of the 1980 edition of **"World Record Game Fishes"** has been announced by the International Game Fish Association, 3000 East Las Olas Boulevard, Fort Lauderdale, FL 33316. Completely updated, the 288-page volume contains rules for the new World Record Freshwater Fishing Contest, which marks the beginning of the first comprehensive international program for freshwater records. Rules have also been revised for the annual saltwater contest to encourage anglers to demonstrate their interest in species not currently included on the world record list.

The records listing is fleshed out with interesting articles on sportfishing and conservation, selecting a fly fishing outfit for fresh or salt water, an overview of the results of the marine game fish tag and release efforts in the Atlantic Ocean by Frank Mather, an illustrated history of the IGFA, a perspective on outriggers, how fishing lines perform under stress, plus concise but detailed data on the salmonids (salmons, trouts, charrs) and on the tunas and other marine game species. Appendices provide data on fishing knots, splicing multifilament line, saltwater sportfishing terms, marine gamefish tagging programs, and converting weights and measures. The volume will be of interest to anyone involved in marine angling.

The paperbound book is available from the IGFA for $4.95 plus $1.00 postage and handling.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 1700 Westlake Ave., N., Room 336, Seattle, WA 98109.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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